THE ENGINEERING JOURNAL

INDEX

Volume 46—January To December 1962

AUTHORS

THE ENGINEERING INSTITUTE OF CANADA

The Roman numerals below refer to the Supplement in the April 1962 issue "Report of Council for 1961."

SUBJECT

INDEX TO ADVERTISERS

DECEMBER 1962

PUBLICATION OFFICES: The Engineering Institute of Canada, 2050 Mansfield Street, Montreal 2, Quebec, Canada.

Association of Consulting Engineers of Canada Incorporated

The following firms have principals who are members of this Association engaged as professional engineers in engineering work independent of salaried employment or sales promotion.

The revenue derived from the sale of advertising space assists the Institute in publishing THE ENGINEERING JOURNAL on a regular monthly basis. Listed above are the names of the Companies and individuals whose advertisements appear in this issue.

ADVERTISING OFFICES

QUEBEC:	J. E. Donovan, Manager, Advertising Sales. Representative—Charles R. Amey, 2050 Mansfield Street, Montreal, Phone: VIctor 2-8121
ONTARIO:	W. Morrison Day, 160 Eglinton Ave. E., Suite 103, Toronto, Phone: 485-0789
WESTERN CANADA:	W. George Turner, 501 - 191 Lombard Ave., Winnipeg, Man., WH 3-9123
UNITED KINGDOM:	H. A. Mackenzie, 4A Bloomsbury Square, London, W.C.1, England. Phone: HOlborn 3779
EUROPE:	Gustav Elm, 41 Avenue Montaigne, Paris 8, France. Georg Linder, Wittelsbacher Allee 60, Frankfurt Am Main, West Germany.
NEW ENGLAND STATES:	R. G. Melendy, 17 Maugus Avenue, Wellesley Hills 81, Mass. Phone: CEdar 5-6503
CHICAGO:	W. Reynold Ratz, 549 W. Randolph St., Chicago 4, Ill. Phone: ST-2-8811
NEW YORK:	John H. Boyd, 17 East 45th Street, New York, Phone: MUrray Hill 7-0654
CALIFORNIA:	Dunkle/Lehman Company, 740 South Western Ave., Los Angeles, Calif. Phone: DUnkirk 7-6149

THE
ENGINEERING JOURNAL
VOLUME 45 NUMBER 1 JANUARY 1962

PUBLISHED MONTHLY BY THE ENGINEERING INSTITUTE OF CANADA, 2050 MANSFIELD ST., MONTREAL 2, QUE., CANADA • TEL. VI. 2-8121

Printed in Toronto

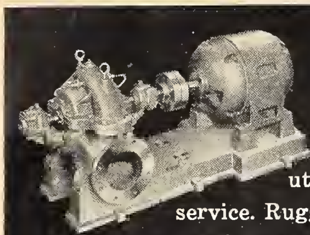
Price $6.00 a year in Canada, British Possessions, United States and Mexico, $7.50 a year in Foreign Countries. Current issues, 75 cents a copy, back issues from $1.00 per copy up. To members, affiliates and other bona fide engineers in Canada—no charge. Authorized as second class mail, by the Post Office Department, Ottawa, and for payment of postage in cash.

MEMBERSHIP

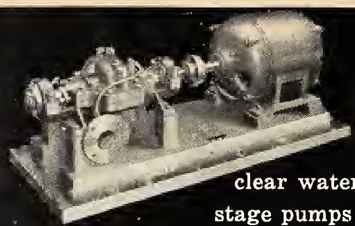
CCAB BNA

Indexed in
The Engineering Index
The Applied Science and Technology Index

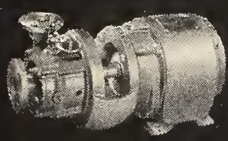
CONTENTS



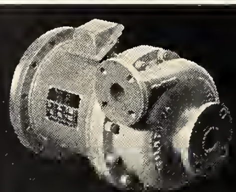
Clear Water Pumps—Double suction pumps designed for utmost efficiency in clear water service. Ruggedly built for dependability, minimum maintenance and down time. Send for Bulletin 955.



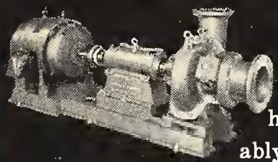
High Pressure Pumps—Ideal for boiler feed and other severe clear water service. These multi-stage pumps operate against heads to 1500 ft. Capacities to 900 gpm. For complete facts, write for Bulletin 980.



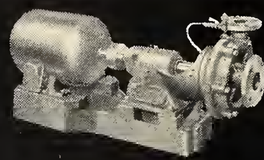
Close-Coupled Pumps—These efficient pumps save space, simplify installation. No need for shaft alignment. Vertical or horizontal models. Adjustable discharge angle. Write for Bulletin 975.



NEW! 'Buffalo' Hermetic Pumps—Quality pumps with special bearings for use where leakage would be dangerous or costly. Available in a broad range of materials of construction. Write for full details.



Non-Clogging Pumps—Move high consistency liquids dependably and efficiently. Minimize wear and wedging. Inspection simplified by diagonally split shell. Rubber-lined models for moving abrasive or corrosive liquids. Send for Bulletin 953.



Chemical Liquid Pumps—Specially designed for moving most corrosive abrasive or high consistency liquids. Your choice of many types in a variety of trim. Will withstand punishing conditions. Write for Bulletin 976.

Heat Transfer Pumps—These special 'Buffalo' Pumps are designed to handle high temperature liquids. Job-engineered construction includes required alloys, water-cooled bearings and proper packings. Single suction, solid shell design gives peak efficiency. Write for complete details.

GPL*

* True long-range pump economy depends on GPL (Gallons Per Lifetime)...pumped day-in-and-day-out with a minimum of down-time and maintenance costs. This is the kind of long-lived reliability built into every 'Buffalo' Pump. It is the most important result of top quality design and construction.

'Buffalo' offers a complete line of centrifugal pumps featuring parts interchangeability and low maintenance. Whatever your liquid moving needs, chances are there's a 'Buffalo' Pump to fit it perfectly. And your 'Buffalo' resident engineer is the man to recommend it. Contact him, or write us direct.

Write Today for Your FREE Calendar Desk Pad.

"Canadian Buffalo"

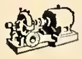
CANADA PUMPS LIMITED

ASSOCIATED WITH CANADIAN BLOWER & FORGE COMPANY LIMITED, KITCHENER, ONT.

ENGINEERING SALES OFFICES: Montreal • Hamilton • Toronto • Sarnia • Ottawa • London • St. John • Winnipeg • Edmonton • Vancouver

"Canadian Buffalo" Air Handling Equipment to move, heat, cool, dehumidify and clean air and other gases.

"Canadian Buffalo" Machine Tools for production drilling and plant maintenance.



"Canadian Buffalo" Centrifugal Pumps to handle most liquids and slurries under a variety of conditions.

IN THIS ISSUE

R. C. Langille, author of *The DRB Topside Sounder Satellite* is Superintendent, Electronics Laboratory, Defence Researeh Telecommunications Establishment, Ottawa. Born in Yarmouth, N.S., Dr. Langille received a B.Sc. from St. Francis Xavier University in 1937. In 1940 he graduated from Dalhousie University, Halifax, N.S., with an M.Sc., and in 1944 obtained his Ph.D. from the University of Toronto. On graduation he joined the Canadian Army Operational Research Group where he performed researeh in radar meteorology. Dr. Langille has been with the Defence Research Board since 1947 when he joined the Defence Research Telecommunieations Establishment. Here he has done research in radar meteorology and tropospheric propagation. His paper describes the design of the experiment and the construction of the 275 lb. Topside Sounder satellite package which is being designed and built in Canada. It will be placed in orbit, early this year, by a rocket supplied by the National Aeronautics and Space Administration of the U.S.A. The Defence Research Telecommunications Establishment decided to build the Topside Sounder satellite in order to obtain more knowledge of the upper part of the ionosphere over northern Canada which will be useful in radio communication studies.

"The trend towards centralized eontrol and automatic operation of steam power plants began about 10 or 15 years ago," **P. A. Pasquet**, M.E.I.C. states in his paper entitled *Centralized Control and Automatic Operation of Steam Power Plants.* Centralized control of such plants is discussed in detail. Examples of problems encountered and suggestions concerning items to be considered when designing a centrally operated power plant are given by the author. "The purpose is primarily to determine whether the operating efficiency is as good as can be expected under prevailing conditions," Mr. Pasquet writes when considering performance monitoring of such plants. Automatic operation is mentioned only briefly, because the high cost of digital computers and other specialized equipment is felt to be an inhibiting factor in the construction of automatically operated plants in Canada. Mr. Pasquet graduated from Queen's University with a B.Sc. degree in 1942. Upon graduation he joined H. G. Acres and Company and was appointed chief project engineer, Thermal Division, in 1959. The following year he became a partner in the firm of W. P. London and Partners.

The Resistance of Aluminum to Concrete, Stucco and Brick Mortar — Ten Year Test Results is a comprehensive report of "a comprehensive testing program to acquire information about the performance of aluminum embedded in the common alkaline building materials over long periods". The observations and conclusions derived from this program, instituted at Aluminium Laboratories Limited, Kingston, in 1945 confirm the results of a similar set of experiments done previously by Fischer and Vosskuhler. All three authors are with Aluminium Laboratories Ltd. **I. H. Jenks** is head of the Publications Division while **T. E. Wright** is a member of the Chemical Division of which **H. P. Godard** is head. Mr. Jenks is a graduate of Mount Allison University in both Arts and Science. From 1942-1945 he was a chemist for the Aluminum Company of Canada, Limited, Arvida. In 1945 he joined Aluminium Laboratories Limited, Kingston, as a technical writer and two years later became head of the Publications Division. A past chairman of the Society of Technical Writers and Publishers, Mr. Jenks is also a member of the Chemical Institute of Canada, the American Chemical Society and the American Documentation Institute. Mr. Wright graduated from McMaster University with a B.A. in Chemistry in 1942. He joined the Chemical Division of Aluminium Laboratories Limited, Kingston in 1947 and has been engaged in corrosion work on aluminum alloys. Dr. Godard holds a Ph.D. degree in industrial and cellulose chemistry from McGill University and a Master's degree in chemical engineering from the University of British Columbia. An industrial chemist, he worked with wood pulp, copper and gold mining and explosives before joining Aluminium Laboratories, Limited in 1945. Since then he has been mainly concerned with the corrosion behaviour of aluminum and has published some 20 papers on this subject.

Douglas Fir Plywood Manufacture by **J. S. Abel**, gives an outline of the engineering phases of the plywood manufacturing process for Douglas Fir Plywood. It describes the general design of a plywood plant, type of buildings, steam and electrical supply, plant arrangement, and manufacturing equipment involved. In addition to the engineering features it describes a number of the process steps with which the engineering is closely related. The author was born in Dutch Guiana, South America. He attended schools in Cambridge, Mass., and graduated from the University of Manitoba in 1921 with a B.Sc. in civil engineering. Mr. Abel is a consulting engineer in Tacoma, Washington.

In his paper, *Have We A Problem In Engineering Education?* **W. F. McMullen**, Engineering Personnel Manager, Canadian General Electric Co. Ltd., reviews the present day difficulties encountered in engineering education. Mr. McMullen graduated from the University of Toronto in 1935 in electrical engineering. After a short period on the U. of T. staff, he joined Canadian General Electric. He has had extensive experience with CGE in engineering, manufacturing and commercial activities. He was appointed to his present position in 1948. His responsibilities include the recruiting of engineers as well as the operation of technical training programs and related advanced lecture courses. As such, he visits all Canadian Universities, Technical Institutes, and some European Schools.

During the last decade the use of open ponds for the treatment of raw sewage has spread rapidly in the western United States and to Canada. **D. R. Stanley**, M.E.I.C., Consulting Engineer, Stanley Grimble Roblin Ltd., Edmonton, and **E. J. Cole**, M.E.I.C., City Engineer, City of Saskatoon, discuss this practice in their paper *Sewage Stabilization Ponds for the City of Saskatoon.* These sewage ponds have sufficient surface area to assure aerobic conditions, but in recent years short detention ponds have been built to provide anaerobic biological treatment. Some pressure has been exerted on the City of Saskatoon to treat its sewage and a study of the problem has been made.

COVER ILLUSTRATION

Shown is The DRB Topside Sounder Satellite, designed and built in Canada. (Photo courtesy Defence Research Telecommunications Establishment)

DRB Topside Sounder Satellite

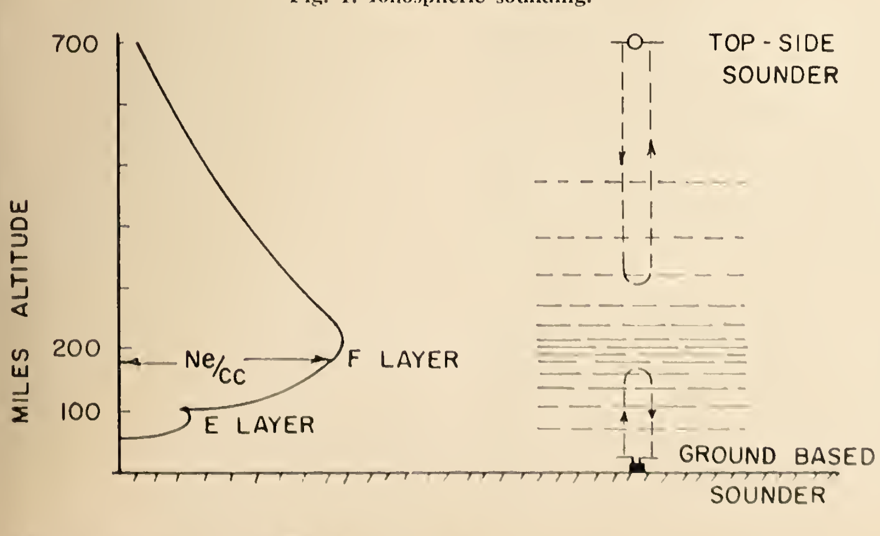
R. C. Langille,
Formerly Superintendent, Electronics Laboratory,
Defence Research Telecommunications Establishment, Ottawa.

Presented at the 75th E.I.C. Annual General Meeting, Vancouver, May 1961.

IT HAS long been known that the sun's radiation, particularly in the ultra-violet and soft X-ray region, causes the rarefied upper atmosphere of the earth to ionize to some extent. The free electrons resulting from this ionization allow the upper atmosphere to reflect and absorb radio waves of certain frequencies. This region which reflects radio waves is known as the ionosphere. The ionosphere is extremely important to communication systems depending upon high frequency radio waves. If the ionosphere did not exist, these frequencies would allow communication only slightly beyond line of sight instead of the world-wide coverage which is usually available. The reflective properties of the ionosphere are not constant, but vary widely with season, time of day, geography and sunspot cycle, and other parameters such as solar disturbances. Solar disturbances are particularly important in high latitude regions, as communications may be disrupted for many days by the disturbed ionosphere. Consequently an understanding of the physics of the ionosphere and the upper atmosphere is very desirable for efficient radio communication.

Canada has unique high frequency communication problems because of her geographical position with a large proportion of Canadian territory lying beneath the ionosphere which is often disturbed. Charged particles streaming to the earth from the sun tend to spiral into the polar regions as a result of the earth's magnetic field. These particles appear to be linked with the aurora and other disturbances of the upper atmosphere which cause the trouble on high frequency radio circuits in high latitude regions. In fact the auroral zone which is a band of maximum occurrence of visual aurora is characterized by an often disturbed ionosphere. This auroral zone passes across Canada from northern Quebec province down over Hudson Bay to Fort Churchill, then north west to the Yukon.

Fig. 1. Ionospheric sounding.



The ionosphere has been studied by radio means since about 1920. The most common method has been to send a pulse of radio waves directly upward, and measure the time required for reflection from the ionosphere. The apparent height of the ionosphere can then be calculated from the time delay. If the radio transmitter and receiver are swept in frequency, usually from about 2 Mc/s to 20 Mc/s, an ionogram showing the apparent height of the various ionospheric layers can be constructed. These ionograms are very useful in studying the changes in the ionosphere and predicting frequencies which should give good results over various circuits. Many countries now maintain routine ionospheric stations to take data on the ionosphere. During the recent International Geophysical Year many routine stations and many special stations co-operated in studying the ionosphere and upper atmosphere. Canada has been taking systematic data on the ionosphere since about 1946 by means of various ionospheric stations which are now all operated by the Department of Transport for studies by the Defence Research Telecommunications Establishment (DRTE).

DRTE has been studying the ionosphere over northern Canada for the past 13 years in an effort to provide a better understanding of high frequency communication problems in Canada, particularly in the auroral zone. Ionospheric data obtained there is usually complicated and its inter-

pretation is frequently difficult or impossible at the present state of knowledge. Consequently it is important to have all the information possible to explain polar events which affect the ionosphere.

Although the lower side of the ionosphere has been studied by radio methods from the earth's surface for many years, there is a serious lack of information concerning the upper side of the ionosphere due to the reflecting and absorbing properties of the ionized layers. Information on the electron density is available up to the height of maximum ionization, but extremely little is known about the ionosphere beyond this point. The diurnal and spacial variation in the electron density under varying magnetic and auroral conditions is also desired with particular emphasis on high latitude effects. At present one can only estimate the electron density above the ionosphere and supplement this information with some rocket data and some indirect measurements, such as the twinkling of radio stars. Rocket measurements are limited to a particular time and place, and do not tell of variations in space or time. Changes in the electron density above the ionosphere as solar particles arrive from the sun would also be of great interest. The DRTE Topside Sounder satellite experiment is designed to supply more information above the ionosphere. Fig. 1 shows a distribution of free electrons per c.c. with height. The curve above the F layer maximum is considerably in doubt. Fig. 1 also shows diagrammatically how the ionosphere will be sounded from above by the Topside Sounder satellite while it is simultaneously sounded from below by ground based sounders.

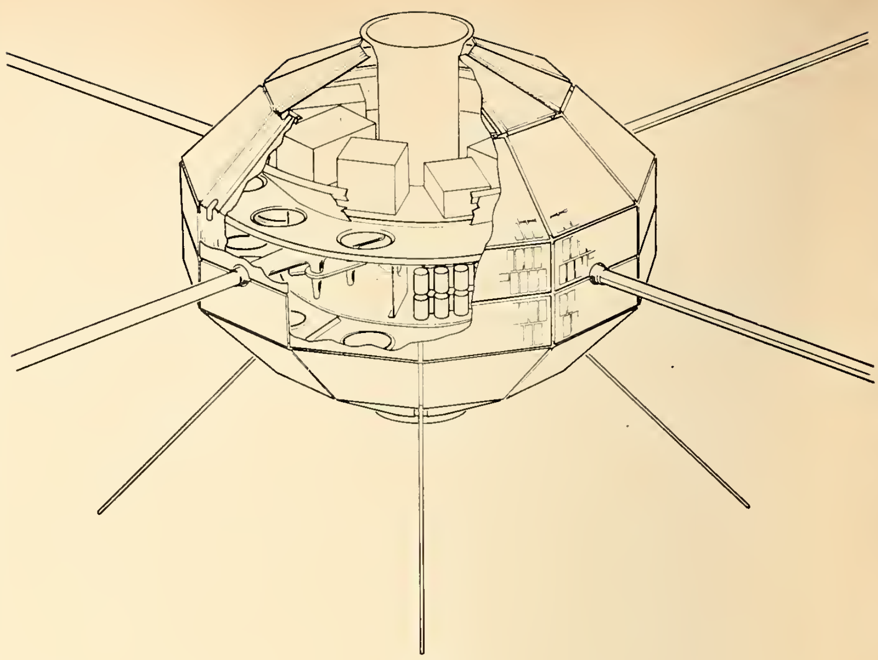


Fig. 2.

Topside Sounder Experiment

As stated above, DRTE has a considerable history in ionospheric research in Canada. Also it has the facility of ground ionospheric stations at St. John's, Nfld., Ottawa, Winnipeg, Fort Churchill, Man. and Resolute Bay, N.W.T. It has a program to study the ionosphere and upper atmosphere by rockets fired from Fort Churchill. DRTE has the knowledge and experience in transistor circuitry, electronic instrumentation and packaging, solid state physics, and environmental testing necessary to design a satellite package. Hence, it is very reasonable that DRTE should participate in a program to study the ionosphere from a satellite. The U.S. National Aeronautics and Space Administration (NASA) has authorized the launching of two satellites, using U.S. launching vehicles, to sound the upper side of the ionosphere by radio means. One satellite will be the DRB Topside Sounder satellite, which is being designed and built by the Defence Research Telecommunications Establishment. This satellite will be a sweep frequency sounder covering the frequency range 1.8 to 11.5 Mc/s. Its operation will be similar to that of a ground ionospheric station.

The other satellite is being developed by a U.S. company, the Airborne Instruments Laboratory, under the scientific guidance of the Central Radio Propagation Laboratory of the National Bureau of Standards. This satellite will sound on six fixed frequencies in rapid succession. The data collected by both satellites will be telemetered to the ground in real time and received at the same ground stations. The DRB satellite will be launched early in 1962 from the Pacific Missile Range in California and the other satellite somewhat later. The data collected by the two satellites should complement each other, but the DRB satellite will concentrate on Canadian problems, while the other satellite will be more interested in studying the ionosphere to the south, in particular along the 75° parallel.

The DRB satellite will be placed in a circular orbit 625 miles above the earth. In order to study special changes in the electron density, the orbit will be inclined at 80°. The orbit will precess clockwise (looking down on the north pole). This will give a complete coverage of local time in a three month period.

The ionospheric sounder transmitter of the DRB satellite will normally be off, and will be switched on by transmitting a command signal from a ground station. The sounder will sweep from 1.8 to 11.5 Mc/s in about 10 seconds. After each 12 minutes of sounding, the sounder will switch off automatically.

Besides sounding the ionosphere from above, the DRB satellite will measure galactic radio noise above the isonosphere over the frequency range 0.5 to 12.0 Mc/s. It will also measure the plasma frequency in the neighbourhood of the satellite by the cut-off of the galactic noise background.

The statellite will carry four particle counters supplied by the National Research Council. These will measure a spectrum of particle energies, and this information will greatly enhance the other ionospheric data because of the connection between ionospheric disturbances and the arrival of high energy particles in the upper atmosphere.

In Canada the information from the satellite will be received at St. John's, Nfld., Ottawa, Resolute Bay, N.W.T., and Prince Albert, Sask. The information from above the ionosphere will be compared with that received at ground ionospheric stations.

Outside Canada the satellites will transmit to U.S. Minitrack stations particularly along the 75° parallel. It is possible that information may also be received at Slough, England and

Singapore. The Canadian interest will be chiefly confined to Canadian territory, in particular the complicated northern situation.

Both satellites will telemeter their data to the earth on a frequency of 136 Mc/s, which is not affected by the ionosphere. The data will be recorded on magnetic tape and Canadian information analysed at a data centre in Ottawa.

The Satellite Package

The configuration of the satellite package is shown diagrammatically in Fig. 2. The shape is a near-spheroid about 42 in. in diameter and 34 in. in height. Total weight will be about 275 lb. A large proportion of the surface is covered with 6480 silicon solar cells which will charge the nickel cadmium batteries through the use of solar energy. The package is designed to yield an optimum of three structural requirements.

(a) The package must be strong enough to withstand the stress of launching.

(b) Achieve as constant a solar cell illumination over the whole package as possible.

(c) Electronic packages and solar cells must be easily removable and separable from the outer shell.

Electronic components are placed on both sides of a load bearing central torus containing the sounding antenna units and battery pack. Attached to the periphery of the central torus are two half shell aluminum spinnings which form the satellite shell. Fig. 3 shows a satellite shell. Onto this spun shell are attached the solar cells panels and end caps. The central torus is attached to the thrust tube through which the entire load is transmitted.

The net result is a vehicle with good mechanical access to solar cells and electronics, and a solar aspect ratio constant to within 10%.

The portion of the satellite not covered with solar cells is especially treated to provide a good thermal balance between a nearly constant room temperature environment in the interior for the electronic circuitry and a cold surface for high solar cell efficiency.

The satellite package except for the electronics is being designed and built by the De Havilland Aircraft Company of Canada to specifications supplied by DRTE. The electrical design of the sounding antennas has been performed by the Sinclair Radio Laboratories.

The design of the antennas for the ionospheric sounder required very special consideration. The frequencies being used (2-12 Mc/s) required that a rather long antenna be employed to obtain reasonable efficiency. Design considerations indicated that dipole antennas 150 ft. from tip to tip would be necessary to enable the transmitter to radiate properly. Even with these long antennas matching networks would be necessary to match the antenna over the frequency sweep of the transmitter. No satellite launched to date has employed antennas longer than about 20 ft. Consequently these long antennas constituted a serious design problem. It was finally decided that suitable antennas could be manufactured of thin steel ribbons which were rolled up somewhat like a carpenter's rule and ejected with an electric motor after the satellite was in orbit above the atmosphere. Fortunately the National Research Council had done considerable development on antenna masts of this type some years before and their experience was available, although their masts were limited to about 25 ft. in length. The antenna will consist of a 4 in. wide strip of spring steel 0.004 in. thick. The antenna is formed and annealed into a circular section with an overlapping open seam. When stored inside the satellite this steel ribbon is wound flat on a spool. When the antenna is ejected the tube passes through a fibreglass transition die which allows the tube to spring back into a circular shape. The result is that the 150 ft. dipole is formed of two 73½ ft. steel tapes which have a fair amount of rigidity. Fig. 4 shows one of these tape antennas partly ejected. In order to eject the steel ribbon it is necessary to pull it out with a strip of mylar tape wound together with the steel ribbon. Attempting to push out the steel tape results in binding.

To ease the antenna electrical matching problem there will be two dipoles constructed of the steel tape, one 150 ft. tip to tip and the other 75 ft. tip to tip. The longer antenna will cover the lower frequency band (1.8-4 Mc/s) and the shorter 75 ft. antenna will cover the higher frequency band (4-11.5 Mc/s). These two dipole antennas are mounted at right angles to each other in the central plane of the satellite package. To test the sounding antennas a qualification experiment was performed in which they were ejected from a rocket above the atmosphere and their behaviour measured. This experiment will be described more fully below.

At one end of the satellite, whip antennas will be mounted for the telemetry transmitter, command receiver and the beacon transmitter. Since these services operate on frequencies above 100 Mc/s the antennas are short and do not present any particular problem except that of assuring as wide angle coverage as possible.

Since the payload is expected to operate for one year, it is necessary to charge the nickel cadmium batteries with energy obtained from solar cells on the satellite surface. Six thousand, four hundred-eighty (6,-480) solar cells arranged in 144 series groupings of 45 cells each provide the charging power for four separate 12 battery Ni-Cd battery supplies.

Fig. 3.

Solar cells with a basic conversion efficiency of 9%, operating at a temperature of 0°C and in the arrangement shown (aspect ratio 4.25) supply 22 watts of electrical energy to the batteries. This allows for such factors as micrometeorite damage, transmission losses and a safety margin.

One of the four battery supplies is to provide power for most of the continuously operating circuitry. The remaining three are to operate the commanded part of the instrumentation. These three supplies have capacities proportionally much larger than necessary when considered in the light of charging power per orbit. This excess capacity will be used to supply anticipated sounding power for the greater part of three successive orbits, recharging then taking place over the remaining orbits. Construction techniques developed for presently orbiting satellites will generally be used in all phases of the power source construction. However, thicker (0.012 in.) than average solar cell cover glasses are being used to protect against higher energy electron damage from the lower Van Allen radiation belt.

It was hoped that all the electronics in the payload would be solid state circuitry and contain no vacuum tubes. This is very desirable from a reliability and conservation of power point of view. However since there are design factors which involve parameters about which very little is known, it has been decided that more power must be used in the ionospheric sounding transmitter than may be necessary to get satisfactory data from above the ionosphere. It is felt that the transmitter must produce 200 watts pulse power with 100 μsec pulses 67 times per second. At first it was feared that a vacuum tube would have to be used in the power amplifier due to problems of impedance matching with the antenna network. However it was possible to design a high power all transistor amplifier to meet the specifications. This avoided the high power dissipation in the tube heater and the high anode voltages necessary in a tube final amplifier. The final result appears to be a very reliable ionospheric sounder. A general block diagram of the ionospheric sounder is shown in Fig. 5.

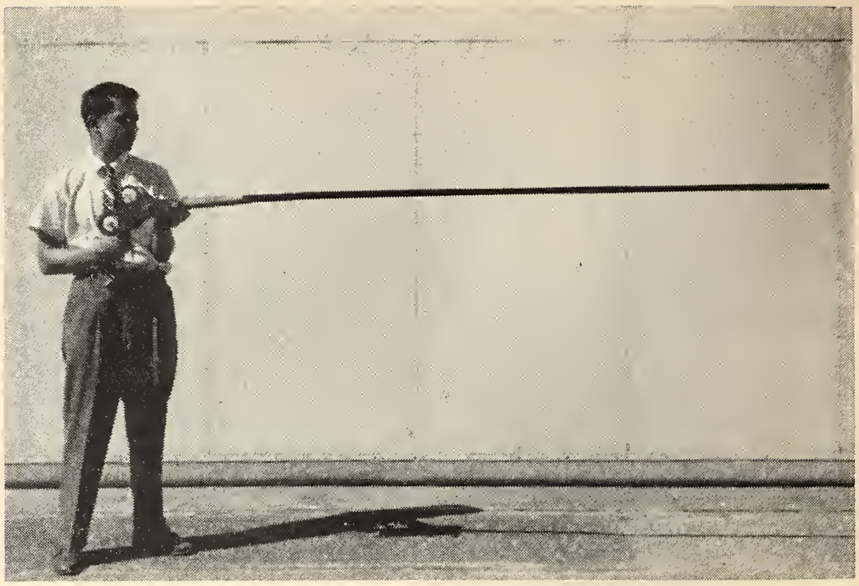


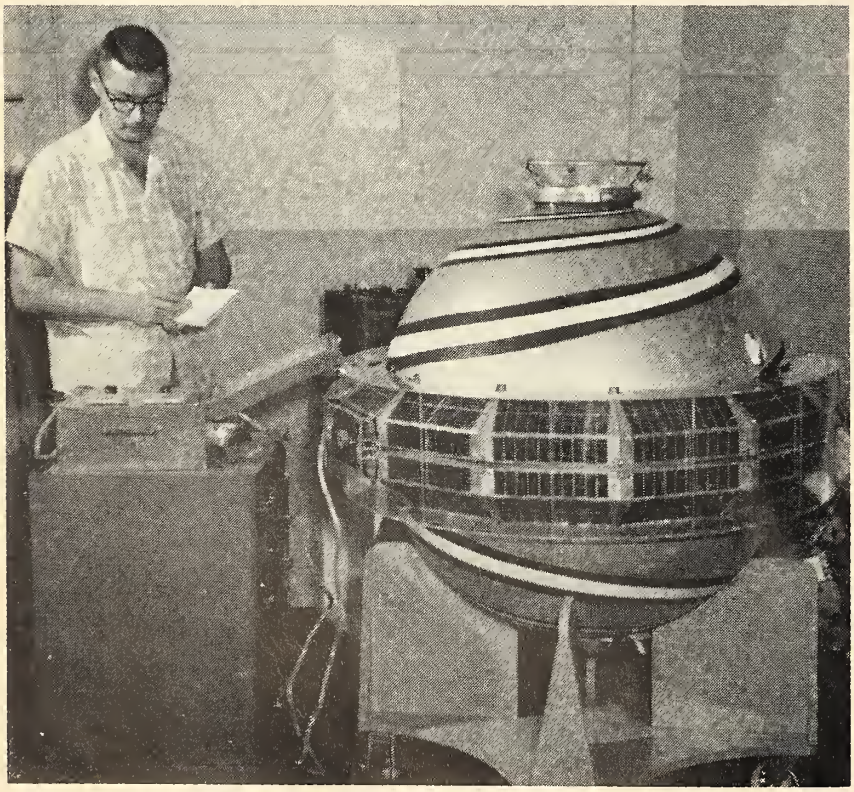
Fig. 4.

Data from the satellite will be telemetered to the ground station on a wideband frequency modulated (FM) link operating at 136 Mc/s. The telemetry transmitter in the satellite will radiate 2 watts of power which should allow a range of 2,000 miles when the ground station uses an antenna with a 19 db gain. Fig. 6 shows the block diagram of the telemetry and command equipment.

The component parts and finally the whole satellite package will be carefully tested for the launching stresses and for space environment. A large environmental chamber which will hold the satellite and allow evacuation to 1×10^{-5} mm. of mercury will be used to check out the satellite package. Simulated sunlight from arc lamps will be radiated through quartz windows into the chamber. The walls of the chamber are refrigerated and infra-red lamps are mounted in a ring around the satellite package within the chamber. With these facilities the satellite can be tested under space environment conditions and can be "soaked" under high vacuum for weeks in order to degas the package to a reasonable extent and turn up any weaknesses in the components or materials.

A first order thermal design of the package has been completed. As mentioned above, for maximum efficiency the solar cells on the surface of the package must be kept as cool as possible. On the other hand, electronic instrumentation and batteries in the interior of the package must be kept at near room temperature. At times

Fig. 5.



the satellite will be in full sunlight and unless properly designed would certainly become too warm. Thermal insulation between the inner package and outer shell will be obtained by use of fibreglass-paper interleaved with ½ mil aluminized mylar. Computations based on a 30 watt on-off duty cycle giving 10 watts average power were used in the thermal design. Fortunately the time of launch allows a certain amount of control concerning the length of time before the satellite will be in full sunlight. Fig. 7 indicates the result of computations on the thermal design and estimated temperatures of the package. These have been compared with satellites already in orbit and have been found to be of the right order of magnitude.

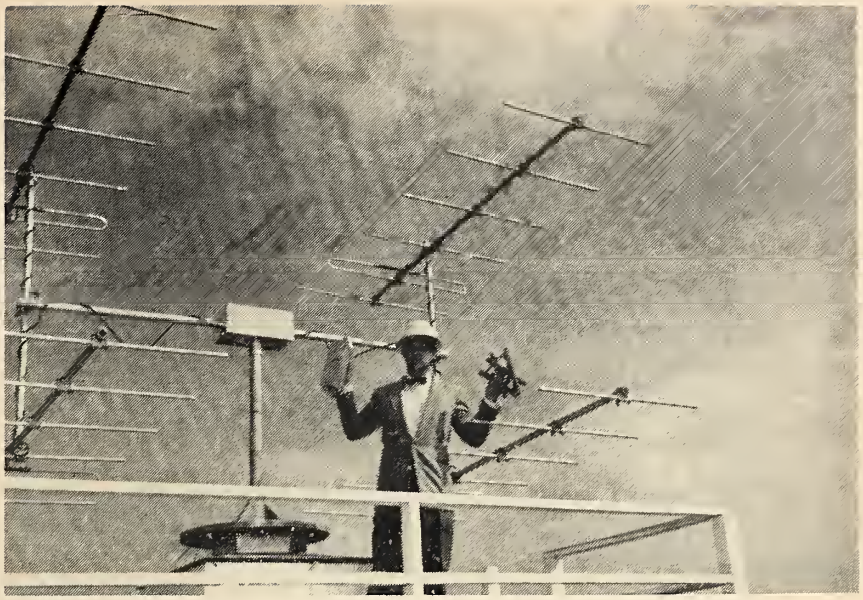


Fig. 6. Dr. Molozzi holds DRTE receiver and antennas used on the Transit 2A Satellite.

Special Experiments to Test the Design of the Satellite

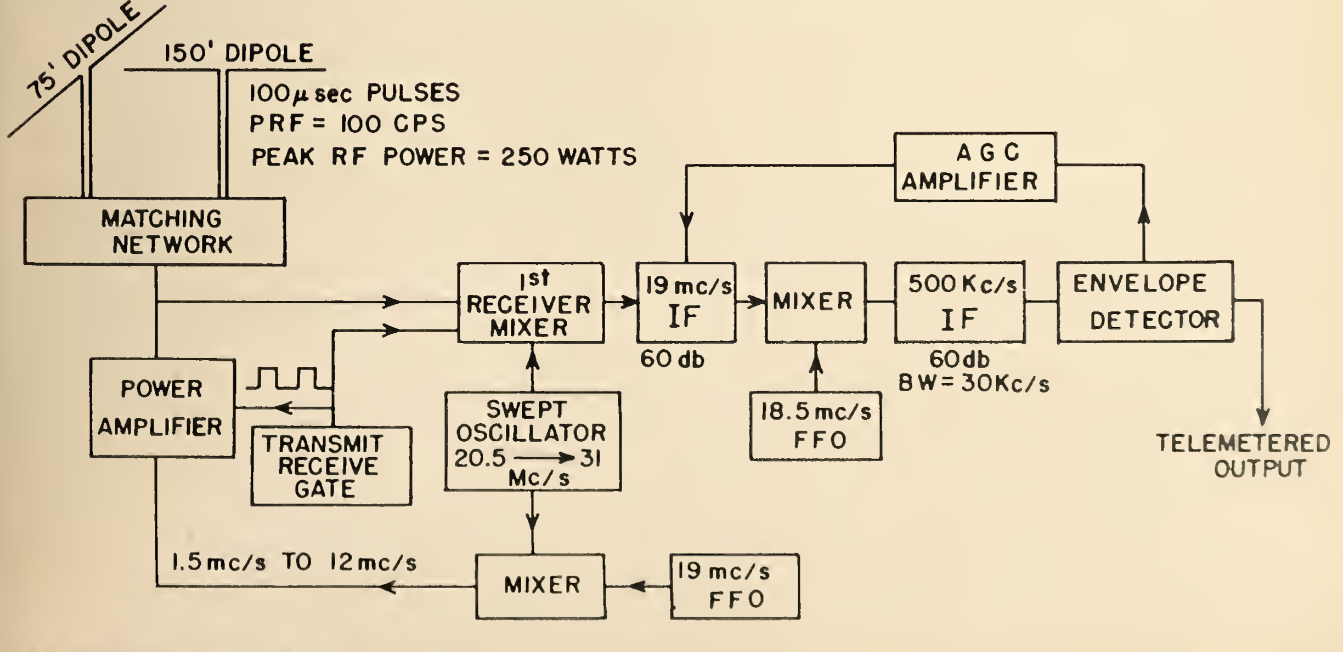
As mentioned above it was felt that the long sounding antennas should be subjected to a qualification test under space environment conditions. Consequently, two 73½ ft. sounding antennas were launched in a Javelin rocket and ejected above the atmosphere. The aim of the test was to check the antennas' mechanical, structural and electrical properties under actual flight conditions. The experiment was designed to provide a dynamic environment as nearly as possible identical to that the antennas would encounter in the satellite. This loading with its transient bending moments would be extremely difficult to reproduce in a ground test. However the rocket did not despin as expected to about 330 r.p.m., but despun to a much lower rate of spin quite suddenly, subjecting the antennas to a much more violent stress than had been planned. Even so the test was a success, one antenna rod extended to its full 73½ ft.; and the other to about 55 ft. Although one antenna rod jammed, the dipole antenna would have operated reasonably efficiently. Corrective design has been applied to the antenna units, and it is felt that the antennas in the satellite will operate satisfactorily.

Early in the system design of the Topside Sounder it was realized that an accurate determination of cosmic noise power level at an altitude of about 600 miles was very desirable.

Through the goodwill of the Applied Physics Laboratory of John Hopkins University DRTE was given an opportunity to install suitable measuring equipment in their Transit 2A satellite placed into a 500 mile orbit in June 1960. Accordingly a single frequency receiver and a pair of ferrite loop antennas were designed and constructed at DRTE. The receiver operated at 3.8 Mc/s and included calibrating circuits. Automatic gain control voltage with a time constant of 0.1 sec. was used as a measure of cosmic noise level. The antennas became part of the Transit 2A despin weights and the Canadian experiment was designed to be completed in the first five to seven days. Fig 8 shows the APL satellite before launch.

Excellent telemetry records were obtained from the Blossom Point, Maryland and the DRTE Ottawa sta-

Fig. 7. Pulsed system for top-side sounder.



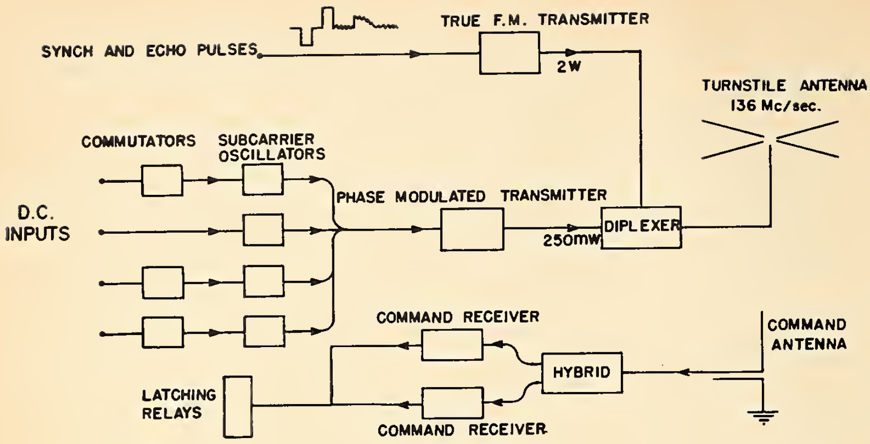


Fig. 8.

tion. Good records were also obtained from some other Minitrack stations. Fig. 9 shows the tracking antenna used for the Transit 2A experiment at Ottawa. The noise at 3.8 Mc/s as measured in the northern hemisphere indicated approximately ½ μvolt/meter equivalent broadside polarized field strength in 40 kc/s bandwidth or approximately 10^6°K brightness temperature. There was no indication of variation between day and night passes. On the other hand Woomera, Australia results showed variation of 3 db with the high value being 6 db above the northern hemisphere value. Santiago, Chile, for which only one record of poor quality was received, showed no such increase. At present an explanation is still being sought and the ionospheric data may shed some light on this interesting result.

The error in the above readings is +1 to —5 db. The error is of this form because the DRTE receiver operated near the limits of its sensitivity where increases would be evident but decreases are buried in receiver noise. However this experiment has indicated that the cosmic noise level is no greater (perhaps a few db less) than that predicted by the National Bureau of Standards in the U.S.A.

This measurement of galactic noise from a satellite was the first ever performed anywhere and provided very useful design data for the Topside Sounder satellite.

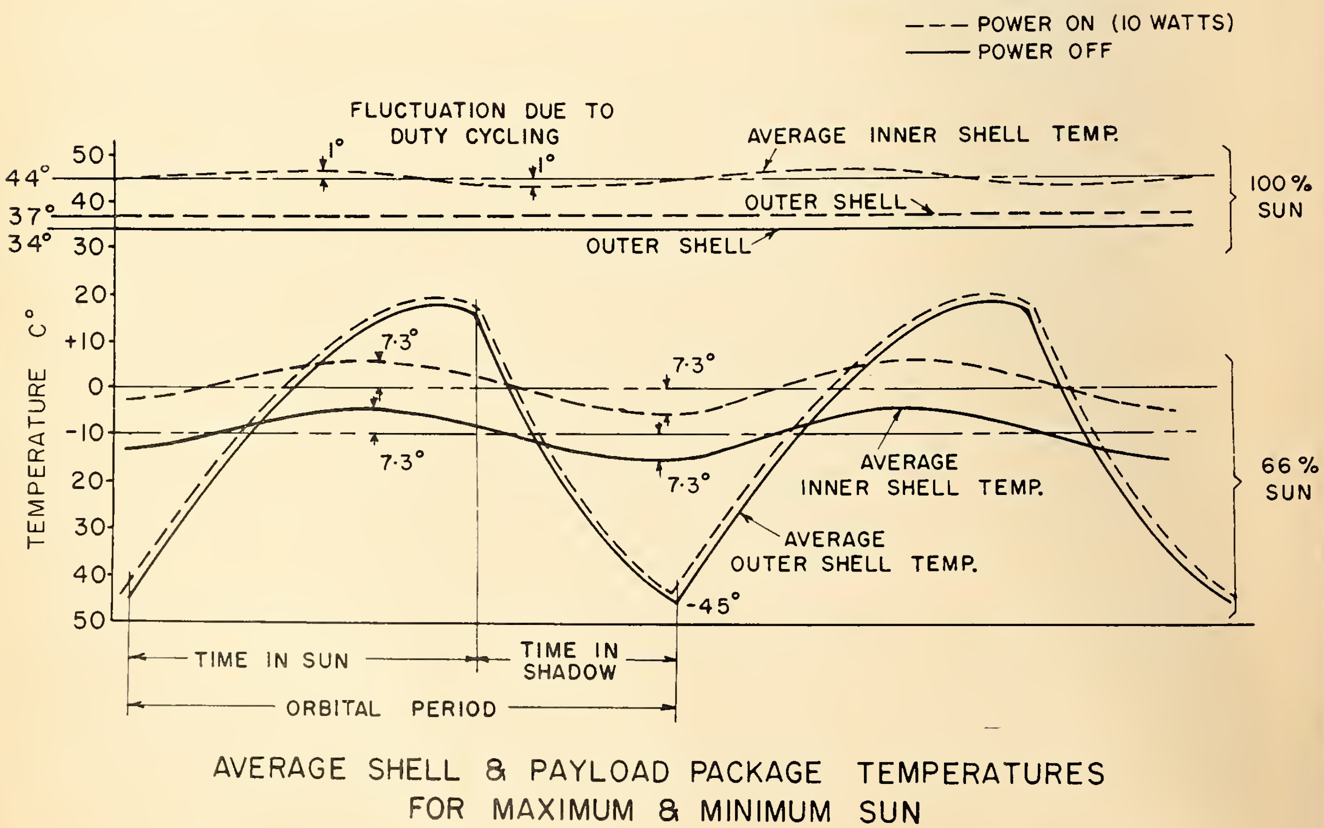
Summary

There do not appear to be any problems remaining which cannot be lems remaining which cannot be solved. Four satellite packages are being constructed, two for testing and two which will be complete flight models. One of the latter will be used for launch in 1962, the other being the required 'back-up'. There is no doubt that satellites will play an ever-increasing part in scientific investigations in the upper atmosphere and later for communications and other important uses. The experience gained in the Topside Sounder program will be very valuable to the Defence Research Board and to Canada. The scientific information obtained will certainly help in gaining an understanding of communications problems in the north country.

Acknowledgement

Many individuals are contributing to the DRB Topside Sounder program and it may be said that almost everyone in the Defence Research Telecommunications Establishment is involved to a greater or lesser extent. It is not possible here to mention everyone by name but it should be pointed out that this is definitely a co-operative project.

Fig. 9. Average shell & payload package temperatures for maximum and minimum sun.



Centralized Control and Automatic Operation

STEAM POWER PLANTS

P. A. Pasquet,
W. P. London and Partners
Consulting Engineers
Niagara Falls, Ontario

THE TREND towards centralized control and automatic operation of steam power plants began about 10 or 15 years ago, when the "unit" arrangement generally replaced the "header" type of plant.

Arrangement of Controls

Most of the stations built in the early 1950's, including the J. Clark Keith and original R. L. Hearn stations of the H.E.P.C., were designed on a unit basis with the boiler and turbine control panels for each unit located on the operating floor near the turbines. Although the manual-auto controls were arranged on the control panels or benches, most operating functions such as starting pumps and inserting burners were performed locally.

The next development consisted of the addition of enclosed control rooms, in which were located the instrument and control panels for two or more units or for the entire station. The Brandon station of The Manitoba Hydro-Electric Board is a typical example of this arrangement. This is a 4-unit plant with a central control room located between Units 2 and 3. The control room houses all the necessary instruments and controls for the normal steady load operation of the entire station, with the exception of such accessories as water treating and coal handling. Although it is not possible to start the boilers or turbines from the central control room, sufficient instruments and means of communication are provided to permit the direction of all operations which must be performed locally during startup or other transient conditions.

In more recent years the trend has been towards complete centralized operation, and the Saint John plant of The New Brunswick Electric Power Commission is an example of this type of installation. This plant is designed for two-shift operation and all the instruments and controls necessary for the operation of the plant in this fashion are located in the central control room. This includes the controls for firing the boiler, starting and stopping the turbine, and for the operation of all motors and auxiliaries. Incidentally, the term "central control room" is not strictly correct in this case, since this room is located in the administration section, which will be at one end of the plant when all the units are installed.

The most advanced development towards centralized control and automatic operation is evident in some of the large American steam power plants such as the Little Gypsy plant of the Louisiana Power & Light Company, and the Huntington Beach plant of the California Edison Company. These plants include completely centralized instruments and controls and digital computers to supervise and direct all operation in accordance with preset programs. To the best of our knowledge these plants are not operating on a fully automatic basis as yet, but more and more operating functions are being turned over to the computers as the programs are perfected and proved.

Control Hardware

The development of the central control room type of plant would not have been possible without the availability of pneumatic and electric transmitters, and of compact instruments and controls. The use of transmitters provided the designer with almost unlimited freedom in locating the various control components, and the more compact equipment facilitated the grouping of the necessary instruments and controls within the limited confines of a control room and within convenient reach of an operator.

As additional control functions are centralized, the amount of information required increases and the provision of sufficient convenient panel space is an ever present problem. In the Saint John plant most of the recorders and some of the indicators have been replaced by data-logging equipment. As well as saving valuable space the data logger relieves the operators of the necessity of manually logging operating data.

In recent years both analog and digital computers have become available for power plant use. Analog computers can be used to optimize the operation of conventional automatic controls and to reduce data to a readily understood form for operator guidance. Digital computers can perform the same functions and, in addition, can be used to program or monitor sequential operations.

There are many advantages to be gained through the use of automatic control, but the main one is safety. The ability of the computer to monitor, absorb, and digest information is almost unlimited and, assuming that the unit is correctly programmed, in case of emergency appropriate action will be taken immediately. The only limitation is the ability of the operation and design engineers to foresee all eventualities, since once a problem is recognized an optimum program can be developed for its solution. In contrast to this, manually-operated plants depend on the ability of one operator, under stress, to read and interpret instruments and, based on his own experience and knowledge, to take the right action.

It should also be noted that the point has been reached where hardware is available to perform almost any control or operational function which could possibly be required in a steam power plant. The designer's main problem is in deciding what operations must be performed and what equipment to use to ensure maximum reliability and economy.

Centralized Control

We agree with the trend towards centralized control, but based on recent experience we would suggest the following points for consideration when designing a steam power plant for centralized operation:

(a) The design of the equipment should be reviewed to ensure its suitability for remote control to eliminate all nonessential control functions.

(b) Manual controls should be eliminated or simplified wherever possible through the acceptance of automatic controls.

(c) The information provided in the central control room should be in its most useful form.

The suggestion regarding the review of major equipment recognizes that the designers of boilers, turbine-generators, and steam power plant auxiliaries deserve credit for the reliability and efficiency of the equipment that they produce. However, some of the development took place before the importance of centralized control was fully realized, and the problem of remote control has been solved by the addition of control drives of various types to replace manual operations.

Some functions which were reasonable when manually performed by an operator standing near the equipment become complicated and expensive when performed by motors, cylinders, diaphragms, or solenoids. A few examples of some of the centralized control problems encountered in the design of the Saint John plant are outlined hereunder.

(1) Boiler vents and drains — The boiler is provided with numerous small vent and drain connections on the steam drum, superheater headers, economizer headers, etc. Most of these valves are required only for maintenance or for cold startup after a long shutdown, and a few are required during a startup following a normal weekend or overnight shutdown. In this case since remote control of startup operation is required after a short shutdown only, it was necessary to motorize only five vent and drain valves. However, this still represents an appreciable investment and, if the plant had been designed for fully centralized control, it is apparent that the number of valves requiring remote operation would have been much larger.

(2) Turbine loop pipe drains — The turbine is arranged with four loop pipes between the turbine valves and the steam chest. During startup, all of these loop pipes and the steam chest must be carefully drained to avoid any possibility of condensate admission to the turbine. In the past, locally controlled turbines of this type were provided with valve tables from which were controlled master and martyr valves for each of these drain points. However, in this case the provision of motor operators for the control of all these valves did not appear reasonable, and only one valve per drain was motorized. The suitability of this arrangement will be proven by experience, but turbine modifications to simplify the drains problem should certainly be considered.

(3) Boiler secondary air registers — The Combustion Engineering-Superheater boilers are provided with secondary air registers at each burner. In the case of the Saint John boiler, the operation of these registers required 28 electric motors controlled through seven multi-position manual control switches. Some large boilers require as many as 88 air register motors. Although there is no doubt with regard to the efficiency of the burners, the possibility of reducing the number of components and controls deserves consideration.

(4) Turbine barring gear — The remote operation of the turbine barring gear required extensive redesign of this equipment and the development of instruments to indicate the turbine speed in the very low ranges, including positive indication that the turbine is stopped.

(5) Condenser air ejectors — The conventional two-stage, twin-element air ejector provides an example of equipment which does not lend itself to remote operation. In the first place, in order to utilize the inherent flexibility of the equipment, remote control of four steam valves and four air valves must be provided. Secondly, due to the provision of common inter- and after-condensers, the operation must be carefully sequenced and interlocks provided to avoid loss of vacuum or dangerous excessive pressures.

The use of separate single-element air ejectors or vacuum pumps, although possibly more expensive, should certainly be considered.

The second recommendation concerns elimination of manual controls by the acceptance of automatic or semi-automatic control loops. It should be realized that it is not possible to operate a modern steam power plant designed for centralized control if the remote or automatic controls are not operative. The manual controls are supplemental to the automatic controls, and are intended for use only during transient conditions when normal automatic control is not always practical, not as standby equipment. For example, during startup of a boiler it may be desirable to provide manual control of combustion air flow. This should not be construed to mean that the operator must be provided with separate manual controllers which bypass all the automatic control elements and provide individual control of the dampers and variable speed couplings of each fan. A single manual-auto selector with set point control calibrated in relative units would be far more useful to the operator and would take up much less panel space.

Similarly, providing manual control for the fans normally controlled by a fully automatic and reliable furnace draft controller is an unnecessary complication.

The same principle applies to such things as heater hotwell and deaerator level controls. The addition of control loops or sequentially programmed operations should be used to replace as many manual operations as possible. Considerable work has already been done in this direction, as is evidenced by soot blower and burner controls which utilize extensive sequential control systems.

The third recommendation concerns the provision of useful information. It is essential that the information available to the operator be in the most concise form possible. For example, it may be desirable to use the gas pressure drop across the boiler air heater as an indication of relative cleanliness of the air heater as a guide in programming soot blowing operations. An instrument indicating the gas pressure or draft at the inlet and outlet of the air heater can be used for this purpose. However, this requires the mental subtraction of two readings (and the scales are probably different), the comparison of the difference with an indication of load or gas flow, and making the necessary corrections for nonlinearity. A far more useful instrument would be one which indicates the deviation from the expected pressure drop at the operating load. Such instruments can be made up from available components and, in the Saint John plant, this is accomplished with two pneumatic differential pressure transmitters for the air and gas pressure drops across the air heater, a computing relay, and an indicator which indicates the pressure drop coefficient. Both the existence and the degree of fouling of the air heater can be assessed at a glance.

Similar instruments can be provided for boiler draft loss and dust collector draft loss indication. These can all be operated in conjunction with the air pressure drop across the air heater or whatever means are used for measuing the air flow.

Feedwater heaters also lend themselves to the application of instruments to indicate directly the performance of the equipment. In general the performance guarantee for feedwater heaters is based on the terminal temperature difference; that is to say, the difference between the saturation temperature of the steam entering the heater and the temperature of the feedwater leaving the heater. It is possible to determine the TTD from the steam pressure and water temperature. However, since the variations are of the order of one or two degrees, conventional instruments are not normally sufficiently accurate. An instrument arranged to measure the difference in temperature directly, through the use of two resistance elements or thermocouples in the same circuit, would be far more accurate and would provide a reading of instantaneous value to the operator.

This principle of selection of the information to ensure its optimum use should be applied to indicators. recorders, and data loggers where such are used.

In the past the use of digital computers has been considered primarily as part of automatic operation of steam power plants. However, digital computers are now available which, in our opinion, could be used advantageously in conjunction with normal centralized controls. These computers could provide the following operations:

(1) Perform computations not readily adaptable to analog units to reduce information to its most significant form.

(2) Program sequential operations in accordance with preset routines, eliminating numerous interlocks and other electro-mechanical devices.

(3) Program and correlate the operation of the scanning and annunciator systems.

(4) Provide a memory to permit the determination of trends for logging or annunciation purposes.

Performance Monitoring

Performance monitoring is a specialized phase of instrumentation designed to provide information on the operation of equipment. The purpose is primarily to determine whether the operating efficiency is as good as can be expected under prevailing conditions, in order to reduce fuel costs and anticipate equipment failures.

In the case of gas- or oil-fired boilers it is possible to measure the heat input and power output directly, and thereby calculate a unit heat rate which, with due allowances for deviation from standard conditions, can be compared to an expected heat rate.

This arrangement is relatively simple, adaptable to both analog and digitol manipulation and provides excellent information for operational guidance and for establishing starting-up and other procedures. However, as a means of monitoring equipment performance, this method does have some limitations.

(1) It does not provide any information regarding the cause of any deviation from the expected performance.

(2) The accuracy or the repeatability of conventional fuel flow meters and wattmeters is not sufficient to permit the results to be as useful as might be expected.

(3) Malfunctions which do not appreciably affect the unit efficiency, but which may lead to equipment damage, are not detected.

In the case of boilers operated with coal, it is not possible to measure the fuel input with sufficient accuracy to even attempt an input-output balance method of performance monitoring. For these installations it has been proposed to use monitoring ing schemes comparable with boiler and turbine testing procedures. The boiler efficiency is evaluated by the loss method, using a combination of measured values, fuel analysis data, and boiler design data. The turbine cycle heat rate is evaluated by the input-output balance method, using measurements of steam and feedwater flow and enthalpy, and power output measurements.

This system, although it does of necessity separate the boiler and turbine, is subject to the same limitations as the direct measurement method previously described.

In our opinion the performance of a unit as a whole can best be evaluated as a function of the performance of the various individual components, preferably in conjunction with a unit performance measuring scheme as described above. This approach to performance monitoring has several advantages.

(1) Individual equipment maloperations which might be undetectable from variations in unit performance are usually readily identified.

(2) When maloperations are detected, sufficient information is usually available to locate and evaluate the problem. This permits the operator to decide whether remedial action is required immediately or whether it can be postponed until a more convenient time.

(3) Sufficient information is provided for accurate efficiency calculations, should these be required.

It might be argued that performance variations which cannot be detected as changes in the unit heat rate are insignificant. In our opinion this is a fallacy, since no one expects to measure the unit heat rate to a fraction of a percent, and yet that portion of the annual fuel cost of a steam power plant could be a very significant item.

Automatic Operation

As mentioned earlier, steam power plants designed for automatic operation are being built in the United States, but it is doubtful that such plants can be justified in Canada in the immediate future. However, most new plants in Canada will probably be designed for completely centralized control and performance monitoring with limited application of digital manipulation. This arrangement will provide for reasonable efficiency and reliability while avoiding the large capital cost of providing the digital computers and other complications necessary for automatic operation.

Bibliography

A few of the many recent papers on the subject of power plant control are listed hereunder:

(1) **Computer Application to Power Plant Automation**
F. V. Lyle, Daystrom Incorporated
AIEE No. CP-60-1167

(2) **The Systems Approach to a Computer-Controlled Generating Plant**
Gaines, Kennedy, and Spielberg, General Electric Co.
AIEE No. CP-60-1165

(3) **Look at Generating Station Automation**
R. A. Baker, Public Service Electric and Gas Co.
Combustion—September 1960

(4) **A Digital Computer and Input Requirement for Unit Performance Calculations**
Jenkins and Kunzman, Leeds & Northrup Co. AIEE No. CP-60-1166

(5) **Automation — The Application of Computers to Automatic Boiler Operation**
G. W. Kessler, The Babcock and Wilcox Co. ASME No. 60-PWR-1

(6) **Steam Turbine Generator Automation**
E. G. Noyes and J. D. Davidson, Westinghouse Electric Corporation
ASME Publication

(7) **An Optimizing Computer Controller for the Electric Utility Industry**
L. K. Kirchmayer, General Electric Co. ASME No. 58-IRD-2

(8) **Central Station Control — Automatic Starting of Boilers and Turbines**
W. A. Summers, Ebasco Services Inc
Second ISA Conference 1959

(9) **The Principles of Automatic Control**
A. Porter, Dean of Engineering University of Saskatchewan. The Engineering Journal, September 1960.

EIC

DOUGLAS FIR PLYWOOD MANUFACTURE

John S. Abel,
Consulting Engineer, Tacoma, Washington

Described is the general design of a plywood plant, including the type of buildings, steam and electrical supply, plant arrangement and manufacturing equipment involved. In addition, notice is made of process steps with which this engineering is closely related.

Presented at the 75th E.I.C. Annual General Meeting, Vancouver, May 1961.

THE GENERAL plant design of a plywood plant is relatively simple; the operation and plywood manufacturing process less so. Plants are in nearly all cases single story wide aisle timber framed structures with concrete floors and built up roofs. They may or may not be pile supported, depending on the value of the soil. In most cases, however, lathes and presses in the areas in which I am familiar are supported on piles on account of the load and the importance of a good solid foundation. The earlier plants had timber Howe trusses 80 ft. to 100 ft. span which were replaced in later designs by timber bowstring trusses and now the tendency is towards glued laminated beams with glued laminated columns.

Electrical distribution is at incoming line voltage to load centers where it is stepped down at unit substations to 440 volts. Practically all equipment in the plants with which I have had experience is 440 v., 60 cy. A.C. Air compressors are a necessary adjunct to any plywood plant as the demand for compressed air is insatiable or so it seems. Even a small plant i.e. one lathe two dryers one press will probably have two compressors located at opposite ends of the plant each driven with a 75 hp. motor and delivering 350 cu. ft. air. These are usually horizontal type with intercoolers, the system delivering air at 100 lb. Plants always seem short of air, the more mechanical devices that are added the shorter the supply. The amount of air that is used in cleaning up and blowing down equipment is the despair of an owner. Steam in most large integrated plants is supplied by the main power house, in some, the plywood plant has its own power house.

Auxiliary equipment apart from the main plywood plant but forming a necessary part of the operation is the knife grinding room for chipper knives, lathe knives, clipper knives etc. Saws may be filed in the plant or where they are carballoy they are sent out to the manufacturer for sharpening and setting. Veneer chippers and core chippers, while playing no part of plywood manufacture, are a necessary adjunct to the plant where chips are produced from the waste for sale to others. Quality control of the product requires a small laboratory for testing and evaluation, and an office for plant administration, and perhaps a lunch room will have to be provided.

Plant arrangement should receive a great deal of attention and study. Not only must the various pieces of equipment be the proper selection but the location within the plant should be such that material can be readily transported with a minimum of effort. There are many changes now taking place in the plywood business and no plant should be designed today wherein the designer does not foresee and provide for these changes. Location of equipment should allow for all possible latitude for making changes and areas around the equipment should not be crowded. There is much which cannot be foreseen but there is much which can, and where possible due consideration for such should be given. Balance of the plant is of extreme importance and machinery selection must be a combined effort of designer, operator and owner. Utmost flexibility must be obtained so that a varied range of plywood products can be manufactured to suit a changing and sometimes fickle market.

Miscellaneous Comment

In the preparation of this paper I found several problems. One is that this paper must be worthy of presentation in a national engineering society, it must not be too technical for those unused to the plywood business, it must stress the engineering phases and yet tell something about the manufacture of a rather common product. I will try and tell the story in such a way that the engineers

will be interested and plywood people will recognize similarity to a conventional plant manufacturing this product. A second difficulty has presented itself. I find it is necessary to talk in terms of averages and use approximate figures on several occasions. Any one in this industry will understand the reason. There are some differences in Canadian practice and that south of the line which those in the industry will understand. This paper concerns itself with Douglas Fir Plywood only. Problems encountered with other species will not be considered at this time.

Lathe & Peeling

This is the place where the actual work on the block begins and the lathe forms one of the most important pieces of equipment in the plywood plant. Lathes come in various sizes, the nominal 8 ft. lathe, the longer 10 ft. lathe, and the shorter core lathe perhaps are the ones most commonly in general use. The lathe is important because here is the location where the veneer is cut to thickness and a variation would adversely affect the profit of the plant. For the purpose of this paper we are going to consider only the 8 ft. lathe and the smaller 4 ft. core lathe.

After the block is peeled and the clear removed the knots begin to show and the diameter reduced such that excessive deflection is developed in the block under the action of the knife. The block is then removed from the lathe. Where the plant has a core lathe installation, the block is cut in two and the 4 ft. pieces are further reduced on the core lathe. In some modern plants the tendency has been to eliminate the core lathe and use a backing bar behind the block on the big lathe. When the diameter is reduced to the place where deflection is noticeable by the use of retractable chucks on the lathe, peeling can be carried on down to say 6 in. diam. which eliminates the need of a core lathe.

The block length for a nominal 8 ft. lathe with a core lathe following must permit a full 101 in. peel, so that when the block is cut for the core lathe, the core will finish 50½ in. Some mills cut 101 in. plus kerf and provide the blocks so as to develop this length. As bucking of the logs is at best an inaccurate operation, the logs are cut so as to provide the blocks full say 103 in. The lathes are provided with scoring knives to accurately trim back the sheet to 101 in. Plywood plants integrated with lumber mills may have different practices as the logs are, in case of lumber mills, brought in lumber length and are not bucked specially for the plywood plant. Where the plywood plant is tied in with a pulp plant and there is a sale for the chips, that portion of the block trimmed off by the scoring knives on the end of the cut, simply drops off into the veneer waste conveyor headed for the chipper where it is reclaimed as pulp chips.

Our practice has been to insist on a knife length of 110 in. minimum for a nominal 8 ft. lathe to provide maximum flexibility. There are some lathes on the market which do not provide this width. Their use causes lack of flexibility because cutting blocks with any exactitude by ordinary bucking operations is difficult to achieve. Operators usually prefer the ones they are accustomed to but experience has shown these lathes to be pretty much equal in performance.

Lathe knives are changed usually each shift or every eight hours. An 8 ft. lathe operating three shifts can produce the veneer for approximately 6 million ft. ⅜ basis plywood per month. This will require two dryers operating three shifts and one dryer operating two shifts. Two 20-opening presses producing plywood normally marketed with an average mixture of three, five and seven ply stock operating three shifts will balance out the plant. Naturally it is easy to see that plant balance can be badly disrupted with as many variables as there are in plywood manufacture and to talk averages reminds one of the man who drowned in a river of 1 foot average depth. Balance is important when designing a plant and, with the problems inherent in this business, an engineer has to just do the best he knows how.

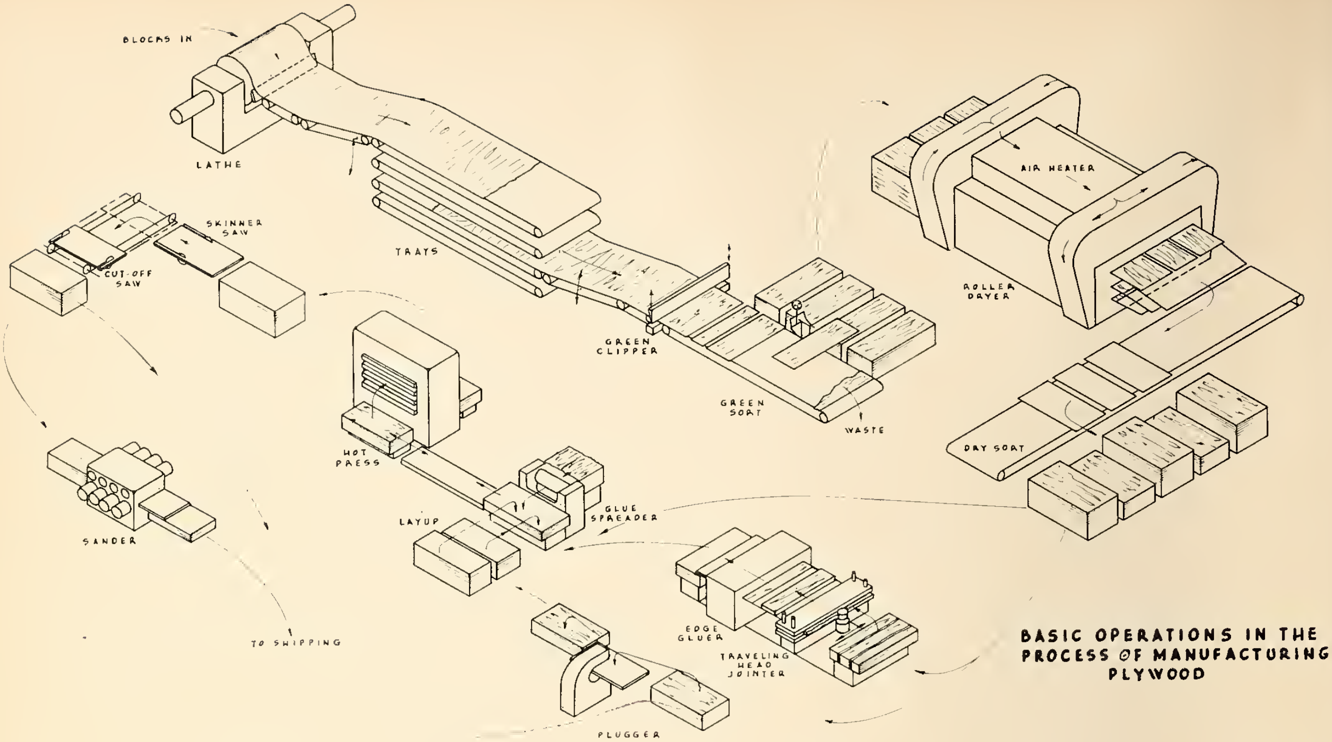
In peeling on the conventional lathe the block is carried down to a 13 in. core with large blocks using a 12 in. chuck and down to 11 in. core with smaller blocks using a 10 in. chuck. If lots of core is required for the constructions being manufactured there is less need to go to the 10 in. chuck as the block will be used up in the core lathe anyway. Lathe swing commonly used is 84 in. although there are lathes made from 60 in. to 110 in. The cutting action is quite simple. Located immediately above the knife is a brass or bronze roller bar running in a continuous backup bearing water lubricated. The veneer comes off the log between the roller bar and the knife. A lathe can peel 450-20 in. to 30 in. diam. blocks per shift if these are of fair quality.

Trays and Clippers

The veneer after peeling on the lathe passes to the trays which are moving belts running at the periphal speed of the block. These form a holding surge bin device from which the veneer is drawn to the clippers. The veneer is fed to the trays by a tipple which automatically or manually delivers the veneer to the one which is empty. The lathe power supply may for example be a 150-175 hp. amplidyne drive and the tipple and trays are geared to it so that they move at the periphal speed of the block. Where there is a variation from this speed the veneer is either torn or bunches up in the trays. There are usually eight trays about 150-160 ft in length following the lathe, four trays feeding each clipper. Clippers are usually on two levels. The top clipper taking the veneer from the top four trays and the bottom clipper taking the veneer from the bottom four trays. There has been some attempt to increase the number of trays to nine and use three clippers, each fed from three trays but this practice is uncommon. Clipper speed with two clippers will usually run about 100-125 linear ft./min. depending on the quality of the veneer; with three clippers it will be 2/3 this speed. Slower speed at the clipper should give the clipper operator a better chance to be more accurate in clipping. However, it is amazing how well an experienced operator can clip and how accurate his work is even at the higher speed.

Green Veneer Storage and Drying

Veneer is pulled manually from the chain following the clipping operation and stored prior to drying. Storage of green veneer usually consists of only such storage necessary to classify and prepare runs for the dryer. After clipping veneer is pulled usually as 48 in. heart, 24 in. heart and narrows. Sap separation is similar to heart separation but in some plants, all sap is pulled together in one lot. Fishtails, i.e., incomplete sheets developed during the roundup, almost in all cases sap, are pulled separately. Normally with douglas fir of the coast region, the heartwood veneer is almost twice the sap wood in total quantity. As these have different moisture contents they must be fed to the dryers separately as they require different drying schedules. They may be run through the same dryers provided that they be kept on separate lines which allow them to be run through the dryers at different speeds. It is common practice where possible to feed full sheets and 24 in. sheets together on the same line as it takes



BASIC OPERATIONS IN THE PROCESS OF MANUFACTURING PLYWOOD

fewer operators. However, where that is not possible, the widths may be combined. In such case with mechanical dryer feeders, two men can keep up with a six line, 20 section dryer with stock consisting of one wide load and two narrow ones. In this case it is better to put the wide sheets in the centre and the narrow ones on the outside. Two men can keep up with sap which runs to narrower widths because the schedule is somewhat slower. When feeding 4 ft. core, the dryer feeder has to handle twice as many pieces because these are half the length but it is an easier job as the stock is nearly all full width nominal 4 ft. sheets or 27 in sheets. Despite the fact that core is nearly always heart and consequently dries on a faster schedule, two men can handle it.

The entering moisture content of heart is usually between 40 and 80%; of sap about 80%. A schedule for douglas fir veneer to produce a finished moisture content of 3% to 5% in the veneer with an 18 section dryer, operating with 150 lb. steam, might be somewhat as follows:—

1/10	Heart	7½— 8	min.
1/10	Sap	15 —16	"
1/8	Heart	10 —11	"
1/8	Sap	19½—21½	"
3/16	Heart	17 —18½	"
3/16	Sap	29 —31	"

Plants with steam at higher pressure and most of them are, could better these schedules somewhat.

Moisture content, the main bugaboo of the forest products industry, is usually determined by a moisture meter which electronically measures the moisture content and marks on the sheet all pieces in excess of the desired precentage. One difficulty with this type of device is that in measuring the moisture content across the 8 ft. width of veneer it will tend to average the moisture content, and a small damp spot which may produce a blow in the finished panel may not be detected if the balance of the veneer is relatively dry.

Dryers in the industry are in nearly all cases roller dryers. The veneer passes through and between rolls within a heated chamber. Source of heat is usually steam served through fin pipes although there are direct fired gas and hot air dryers on the market. There are a few dryers used where instead of passing the veneer through rolls it is laid between wire belts. With the use of dryer feeders which has speeded up the feeding of veneer considerably, the use of these belt dryers is now largely confined to hardwood veneer and sliced veneer for specialty work. Roller veneer dryers usually have two or three zones in which the temperatures may differ. It is not within the scope of this paper to discuss the various theories of drying and the relative merits of cross flow versus longitudinal flow dryers. There are exponents for both, the longitudinal flow being slightly cheaper in first cost.

Dry Sorting

In the conventional mill the dry sort is made from pulling manually from the belt after grading with sorts somewhat as follows:—

Sound 48 in., Sound to be patched 48 in., "C" 48 in., "C" 24 in. "C" narrow, "D" 48 in., "D" 24 in., and "D" narrow. Where white spec is encountered and its use permitted it is pulled separately. The kiln charge being all one thickness, these sorts will be that thickness. Other thicknesses will be sorted similarly when these are being dried.

Patching & Makeup

What a wonderful thing it would be if plywood could be made without having to plug up defects and knot holes! However such is not the case. Defects and splits develop and knots have a way of falling out during drying. Fortunately for the industry automatic machines have been developed which simplify this chore. In face patching, veneer which will make an "A" face is plugged with a boat patch, that which will only grade for a "C" or "D" face is plugged with what is known as a dog bone patch. "B" faces are usually fall downs from "A" faces and consequently have the same patch as the latter. Cores are usually patched with a round or dog bone patch. Faces are made from all widths of veneer edge glued where required. Cores or cross bands are usually 27 in. when produced on the core lathe although narrows are also used in the layup.

After the stock has been made up into faces, backs, etc. and patched as

necessary, it is assembled and stored ready for lay up at the glue spreader. It should be noted that certain types of plywood do not require the defects be patched, consequently the face, back or core destined for that type or grade may bypass this operation.

Gluing

One of the major problems encountered with a conventional glue spreader is the difficulty in maintaining uniformity of spread mainly caused by the deflection of the rolls. In Canada I understand that there is one basic type of resin in common usage namely phenolic resin, a product of phenol formaldehyde. This is used with an extender such as furafil. Certain fractions of douglas fir bark have been used in the United States as an extender with considerable success as far as the development of a sound glue line is concerned.

For 1/8th in. core glue spread will be about 50 lb. per 1000 s.f. double glue line i.e. both sides of the core on three ply construction. Thicker core will increase this figure. Moisture content of veneer entering the press is usually in the 2%-5% range and on leaving the press somewhere about 5%-6%. These figures naturally are approximate but the control is kept at these limits.

Faces are made in one piece by edge jointing the pieces on a jointer and then gluing them together by radio frequency using urea glue. Radio frequency has been replaced in some cases by simply using contact cement with the sheets crowded together in the same manner as in a radio frequency unit. Claims are made for both methods. Another method usable with faces and backs only is to tape these with a paper tape which can be sanded off in the finishing operation.

It might be mentioned that recovery will vary from 1.6 for bad logs to 2.4 for good logs, and is based on ⅜ in. rough. Recovery is the log scale divided by the square feet of plywood on a ⅜ in. basis.

Pressing

The pressing operation in the manufacture of plywood is of importance because it is at this point that the component parts which go to make up the sandwich are united into one complete whole. Temperatures and pressures must be maintained within narrow limits and the proper press schedule must be carefully controlled. Moisture content of the veneer must be right as too wet veneer will produce blows where the excess moisture has formed steam between the sheets of veneer or too dry veneer will not receive the glue. Press schedules are important because of the critical timing of all operations in a plywood plant. As the press usually will control the output of the plant time lost during the press cycle means loss of production.

The moisture content of veneer entering the press is in the neighborhood of 2%-5% and on leaving the press about 5%-6%. The press temperature is held about 285° F. Press pressure with resin adhesive is usually in the range of 180-200 p.s.i. Sometimes the pressure may be eased a few pounds if the panels are to be merely touch sanded. Each operator will develop his own optimum pressures and temperatures depending on plant factors and conditions, and on the stock he is trying to process. Once he has obtained what he thinks is best however, he usually sticks to it.

Perhaps the most common size of press is the nominal 4 ft. x 8 ft. This press has a platen 56 in. wide by 106 in. long which may vary slightly with different manufacturers. The number of openings will vary from 10 to 30. Probably the most common number presently in use is 20. In selecting the size of the press the plant designer should try and work out the balance so that the press will always be capable of handling all of the production of the lathe and dryers. With all the various constructions and veneer thicknesses, and different glues used in the United States, this is a neat trick if you can do it. Presses are of standard manufacture and there are several on the market which are excellent. The ordinary press is actuated hydraulically with a 2000 p.s.i. oil system (usually oil gear manufacture). Medium duty hydraulic oil cooled with a heat exchanger is used, with a reservoir holding 600 gal. Steam for heating the platens is supplied from an outside source usually the plant power house.

Presses in nearly all cases have loaders and unloaders. These are not quite as much of an assist as one might think. Actually one has to load the loader by hand after that the loader mechanically shoves the panels into the unloader. One thing the loader does do it permits the loading to be done several feet away from the hot press itself which makes it a little cooler and easier job.

Trimming, Sanding, repatch and finishing

Plywood after leaving the press is ready for the finishing operations. Panels are taken in a stack to the skinner and cut off saws where they are automatically loaded into a machine which edge saws the panels to width and end trims the panels to length. During this operation the ends are printed, the edges and ends are waxed and in the case of sheathing the face is stamped with an appropriate design. Equipment has been developed to handle this work, including a grade separation to pull defective panels, with one operator.

The plywood then passes to a feeder where it is fed to a sander. This is a multiple drum sander with drums top and bottom set to surface the panel at the proper thickness. A grader at the discharge end of the sander rejects any defective panels and separates any which need patching. Sanding will often expose pitch pockets and other small defects which were not visible in the rough veneer. For this reason the panels having these defects are repatched. Patch lines have been developed to handle the sheets mechanically bringing them to and taking them from the operator which makes this job much easier than it used to be when one man picked each panel from the stack, patched it and carried it to another pile. In the newer patch lines, one man checks the graders mark, routes out the defect and passes the sheet on to the next man who sets the patch and passes it on where it is off borne into a stack for resanding. Sheets which need no patching can be bypassed. Patches are usually for defects and pitch pockets, or shims in case of splits or cracks. These are set with resin which is colorless and where the wood is matched for color the patch is very difficult to detect. As it is firmly glued and tight in place it forms an excellent method of finishing off a defect.

Resanding

The industry is now starting to use wide belt sanders to surface both sides of the panel after patching so that the panel is patched sanded and finished in one operation. Up to now patched panels have been sent to a belt sander where they are handled manually one at a time and each individual patch is worked over. For ease in identifying the patches to be sanded off they are colored slightly for contrast, the color coming off in the sanding operation.

Storage and Shipping

After belt sanding the panels, they are stored and shipped. This is usually within the same building and under cover. Many plants ship by banding and strapping especially where whole car loads form one order. In Canada I believe the practice is to wrap several sheets in a package and ship in this form EIC

The Resistance of Aluminum to Concrete, Stucco and Brick Mortar —

TEN YEAR TEST RESULTS

J. H. Jenks,
Publications Division

T. E. Wright, H. P. Godard, Chemical Division
Aluminium Laboratories Limited
Kingston, Ontario

A COMPREHENSIVE testing program to acquire information about the performance of aluminum embedded in the common alkaline building materials over long periods was instituted at Aluminium Laboratories Limited, Kingston, in 1945. This information is needed because aluminum is used in very large tonnages as architectural and structural materials. Sets of specimens of ALCAN 3S sheet and tubing, 50S and 65S extruded bar, unprotected, and with three commonly used types of coating — clear lacquer, zinc chromate primer and bituminous paint — were partially or completely embedded in blocks of concrete, dummy brick walls and stucco (Figs. 1(A), (B) and (C)), made in accordance with standard construction practice and for exposure in environments commonly encountered by Canadian buildings or their

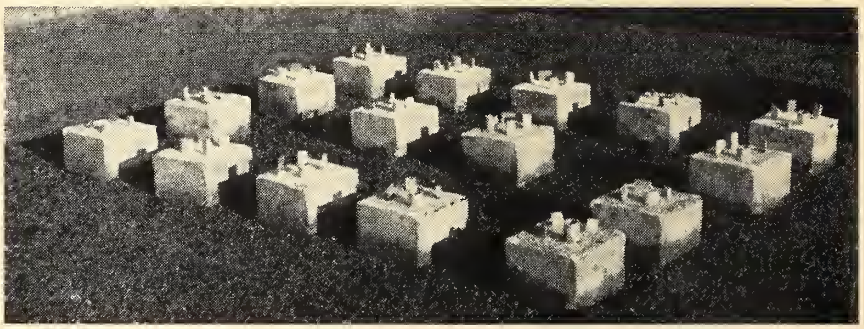


Fig. 1. (A)

ALCAN 3S, 50S and 65S Specimens, some bare and some coated, exposed at the dry, wet and atmospheric test sites, embedded in (A) concrete blocks of 1;33;3 mix, (B) Standard mortar in "dummy" brick walls, (C) plaster on "mocked-up" wall sections.

Fig. 1. (B)

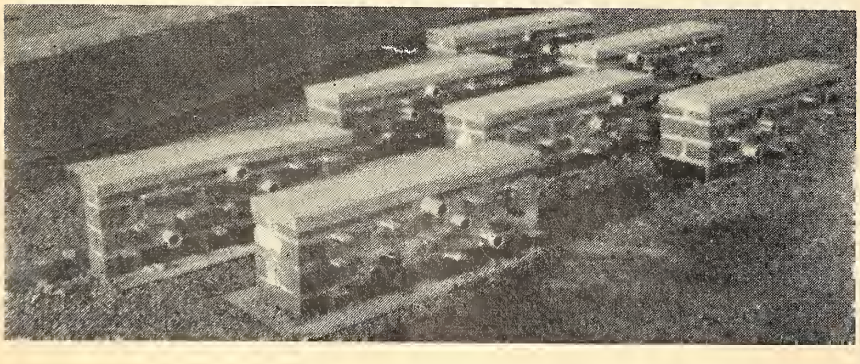


Fig. 1. (C)

components. Sets of specimens were removed after periods of eight days, six and 18 months and 10 years, cleaned and examined visually. In another section of the experiment, weighed specimens of 3S sheet were partially embedded in blocks of concrete prepared from portland cement obtained from the major Canadian cement plants, to check the influence of the source of supply (variation in free alkali content). At the same time, sets of blocks were made with varying cement content, using cements from two sources.

The results of examination after periods up to 18 months showed that aluminum alloys are not seriously corroded by contact with alkaline building materials.[1] The evaluation of the 10 years' exposure has recently been completed and the results are presented below after a short recapitulation of necessary background.

DESCRIPTION OF MATERIALS

The description and nominal composition of the aluminum alloys are given in Table 1. The description and source of the building materials used for the program, with some descriptive remarks, are given in Table 2.

EXPERIMENTAL PROCEDURE

Preparation of Metal Specimens

Specimens of the test alloys were cut into suitable lengths. Those to be lacquered were dipped into clear lacquer and slowly withdrawn to give a coating of 1.0 mil (average) in thickness. Zinc chromate coatings were also applied by dipping to give an average thickness of 2.3 mils. Bituminous coatings were similarly applied to give an average thickness of 6 mils. The specimens were used before the coating had completely hardened as is common practice in the building industry.

Preparation of Concrete Test Blocks

A 1:3:3: (cement:sand:crushed stone) concrete mix was poured into 9 x 9 x 6 in. forms, and specimens were embedded (2 in. protruding) so that each was separated by at least two inches from any outside edge and from one another (Fig. 1(A)). Four uncoated specimens were placed in one block, and separate blocks were used for each set of coated specimens. Sufficient blocks were made to cover the various time periods and coatings and sets were exposed at "dry", "wet" and "atmospheric" test sites.

A second group of sixteen blocks (12 x 12 x 12 in.) was poured with the same mix. Each block contained a totally embedded specimen, 6 in. long, from each alloy and partially embedded specimens, 6 and 18 in. long, from each alloy. Four blocks were used for each test, each containing one set of coated specimens; only one coating was used for all specimens in each block. These blocks were exposed for the two longer time periods only in fresh water and wet soil.

To study the effect of source of cement supply, duplicate weighed aluminum sheet specimens (3S alloy only) were embeded (1½ in. protruding) in duplicate, 6 in. cubes of concrete of 1:3:3 mix made from each of 12 bags, including High Early Strength cement, (six Canada Cement, three independent companies) which constituted the Canadian sources of cement in 1950. Exposure was for one and 10 years in the atmosphere.

Also, to determine the effect of variation in richness of cement in the mix, specimens were similarly embedded in duplicate blocks made from cement from two sources with 1:3:5, 1:2:4, 1:3:3, 1:2:1, 1:3:0 cement:sand:crushed rock ratio (by weight). Exposure was again one and ten years in the atmosphere.

TABLE 1

Description and Nominal Composition of Aluminum Alloys Tested

ALCAN Alloy	Description of Specimens	Composition, Per cent					
		Cu	Fe	Mg	Mn	Si	Cr
3S-H14	Sheet, 2 x 6 x 0.064 in.	—	0.40	—	1.20	0.25	—
3S-F	Conduit, 1¼ in. I.P.S., 6 in. lengths	—	0.40	—	1.20	0.25	—
50S-T5	Extruded bar, 1⅛ x ⅜ in., 6 in. lengths	—	0.30	0.65	—	0.40	—
65S-T6	Extruded bar, 1⅛ x ⅜ in., 6 in. lengths	0.30	0.35	0.95	—	0.60	0.25

TABLE 2

Building Materials for Test Program and their Origin

Material	Origin: Company and Specific Plant	Remarks
Portland Cement	Canada Cement Co., Montreal, Que. Hull, Que. Belleville, Ont. Port Colborne, Ont. Fort Whyte, Man. Exshaw, Alta. British Columbia Cement Co., Victoria, B.C. St. Mary's Cement Co., St. Mary's, Ont.	Water soluble alkalies 0.43% expressed as per cent Na_2O
High Early Strength	Canada Cement Co., Montreal, Que. Port Colborne, Ont. Fort Whyte, Man.	
Medusa White Portland	Medusa Products Company, Paris, Ont.	
Dry Sand	Kingston Sand and Gravel Co.	Passing No. 8 mesh screen
Kingston Crushed Limestone	Frontenac Quarries, Kingston	1 inch size, dry
Lime	Gypsum Lime and Alabastine Co. of Canada, Ltd.	"Green Stripe" finishing lime, water soluble alkalies 0.55% as per cent Na_2O
Hardwall Plaster	Gypsum Lime and Alabastine Co. of Canada, Ltd.	"Paristone", 0.32% soluble alkalies as per cent Na_2O
Gyproc Lath	Gypsum Lime and Alabastine Co. of Canada, Ltd.	
Metal Lath	Local (Kingston) suppliers	24 gauge, diamond mesh, galvanized iron
Water	Kingston City supply	
Lacquer		Conforms to U.S. Army-Navy Aeronautical Board Specification 112, Amendment No. 1 (Resin content methylmethacrylate, clear)
Zinc Chromate Primer		Conforms to U.S. Army-Navy Aeronautical Specification No. AN-TT-P-656B Toluene dilnent
Bituminous Paint		Blended type, coal-tar-pitch base, conforms to U.S. Army-Navy Aeronautical Board Specification AN-P-31

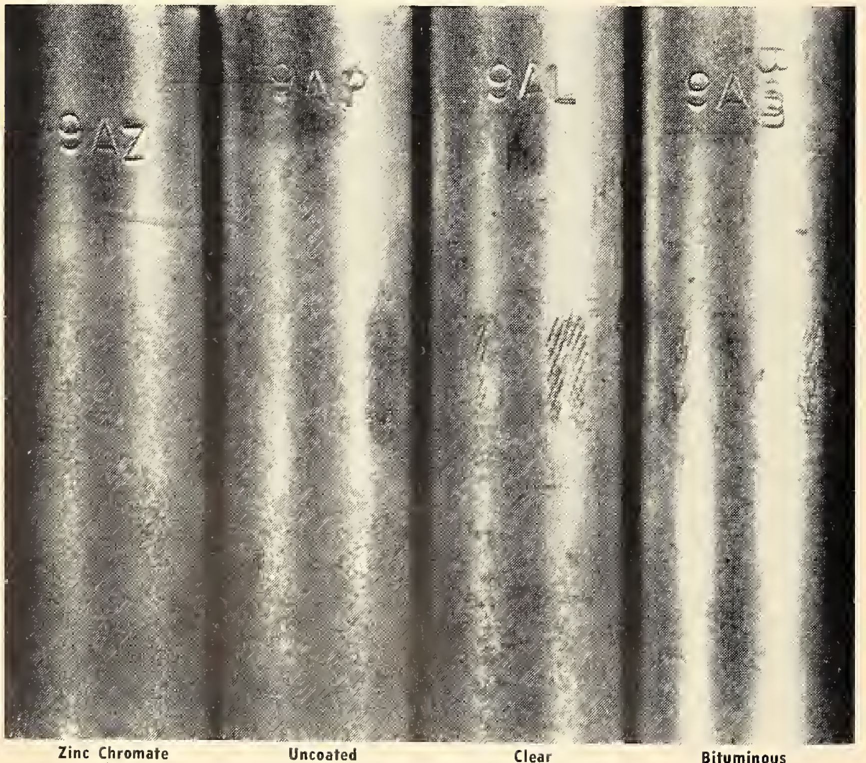
TABLE 3

Condition of Aluminum Specimens Exposed Ten Years

Exposure Conditions	*Specimen Surface Treatment*	*Condition[1] of Blocks*	*Projecting Surface*	*Embedded Surface*	*Max. Pit Depth (mils)*
IN CONCRETE (BLOCKS)					
Dry	Uncoated	NC	Uncorroded	Etched uniformly	0
	Zinc chromate	C	Uncorroded	Etched uniformly[2]	0
	Lacquered	NC	Uncorroded	Etched superficially[3]	0
	Bituminous paint	NC	Uncorroded	Etched superficially[3]	
Atmospheric	Uncoated	C	Normally weathered	Etched uniformly	0
	Zinc chromate	C	Somewhat weathered	Etched uniformly[4]	0
	Lacquered	C	Somewhat weathered	Etched uniformly	0
	Bituminous paint	HLC	Somewhat weathered	Etched superficially[2]	0
Wet	Uncoated	NC	Etched superficially	Etched severely[5]	8
	Zinc chromate	NC	Etched superficially	Etched severely[5]	10
	Lacquered	NC	Etched superficially	Etched severely[5]	8
	Bituminous paint	NC	Etched superficially	Etched[5 6]	9
Buried in wet soil	Uncoated	NC	Etched superficially	Etched severely	
	Zinc chromate	C	Uncorroded	Etched severely[7]	15
	Lacquered	C	Uncorroded	Etched severely	
	Bituminous paint	HLC	Uncorroded	Etched severely	
Immersed in Lake Ontario	Uncoated		Lost	Lost	
	Zinc chromate	NC	Etched severely	Etched severely[5]	25
	Lacquered	NC	Etched severely	Etched severely[2 5]	10
	Bituminous paint	NC	Etched severely	Etched severely[5]	15
IN STANDARD MORTAR (BRICK WALLS)					
Atmospheric	Uncoated		Normally weathered	Medium etched	0
	Zinc chromate		Uncorroded	Etched superficially[8]	0
	Lacquered		Weathered	Etched superficially	0
	Bituminous paint		Uncorroded	Etched superficially[9]	0
IN STUCCO					
Atmospheric	Uncoated		Normally weathered	Etched uniformly[10]	0
	Zinc chromate		Weathered appearance	Etched superficially	0
	Lacquered		Uncorroded	Uncorroded	0
	Bituminous paint		Weathered appearance	Etched superficially	0

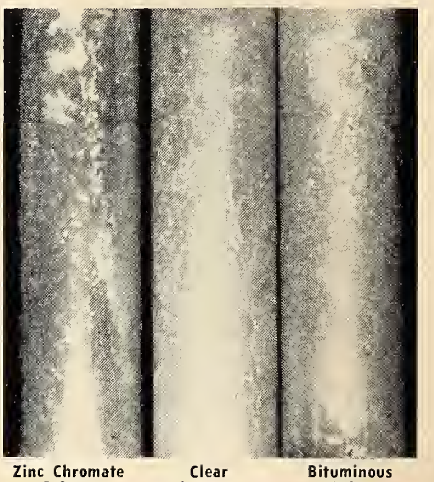
NOTES: [1]NC—Not Cracked; C—Cracked; HLC—Hair Line Cracks.
[2]Narrow etched band about 1/8 in. wide and 2 mils deep, at concrete-air interface of 50S specimen.
[3]No effect on 3S conduit specimens.
[4]Narrow band about 1/8 in. wide and 2 mils deep at the concrete-air inrerface of all specimens.
[5]Numerous pits.
[6]Almost no effect on 3S specimens.
[7]Numerous pits on the 65S specimens; others less affected.
[8]50S and 65S specimens almost unaffected.
[9]50S specimens almost unaffected.
[10]Numerous pits on one surface of one 50S specimen but duplicate free of pits.

Fig. 2. ALCAN 3S Conduit Specimens which were embedded in 9x9x6 in. concrete blocks exposed to the atmosphere for ten years.



Zinc Chromate Primer — Uncoated Metal — Clear Lacquer — Bituminous Paint

Fig. 3. ALCAN 3S Conduit Specimens which were embedded in 12x12x12 in. concrete blocks, immersed in Lake Ontario for ten years.



Zinc Chromate Primer — Clear Lacquer — Bituminous Paint

Preparation of Brick Mortar Piers

The dummy brick mortar piers were made four bricks high, four bricks long and two bricks thick (Fig. 1(B)) with standard mortar as follows: one part portland cement, one part hydrated lime putty, six parts dry sand. The walls were covered by forming a sheet of aluminum into a suitable flashing. Each section (one for each time period) contained 16 specimens: uncoated, lacquered, zinc chromate and bituminous coated from each of the four test materials (3S sheet, 3S conduit, 50S bar and 65S bar). All speeimens passed through the wall. Exposure was atmospheric only and was of 10 years' duration.

Preparation of Stucco Wall Sections

Dummy wall sections of stucco (portland cement plaster) were prepared on frames 48 x 48 in. constructed of wooden two-by-fours with vertical studs at 16 in. centres. Galvanized steel, "diamond" mesh, (24 gauge) was affixed over the frames. The aluminum specimens of the various alloys and coatings were lodged through holes made in the mesh, and the plaster was applied around them. A portion of each specimen measuring approximately half an inch in length was in contact with the plaster. (Fig. 1(C)).

Portland cement plaster, used to simulate exterior stucco where moist conditions are encountered in practice, was made up as follows: one part portland cement, three parts plastering sand, 10% (by weight) water. The specimens in the wall sections were exposed for 10 years on the laboratory roof.

TABLE 4

Metal Loss of Uncoated and Bituminous Paint Coated Aluminum Specimens Exposed for Ten Years

Exposure Conditions	*Surface Treatment*	*Thickness of Metal Specimen Corroded (mils)*[1] *ALCAN 65S Bar*	*ALCAN 50S Bar*	*ALCAN 3S Sheet*	*ALCAN 3S Conduit*
IN CONCRETE (BLOCKS)					
Dry	Uncoated	2.0	2.5	4.0	4.0
	Bituminous paint	nil	nil	nil	nil
Atmospheric	Uncoated	4.0	5.5	5.5	5.0
	Bituminous paint	0.3	nil	nil	nil
Wet	Uncoated	5.5	5.0	2.0	3.0
	Bituminous paint	6.0	2.0	6.0	3.0[2]
Wet soil	Uncoated	3.5	9.0	7.3	7.0
	Bituminous paint	3.0	3.0	1.5	3.0
Fresh water	Bituminous paint	nil	1.5	nil	1.0
IN STANDARD MORTAR (BRICK WALLS)					
Atmospheric	Uncoated	1.0	1.0	0.2	0.5
	Bituminous paint	nil	nil	nil	nil
IN STUCCO					
Atmospheric	Uncoated	0.5	1.0	0.4	[3]
	Bituminous paint	nil	nil	nil	[3]

NOTES: [1] Total losses (both sides)
[2] Metal loss inside conduit
[3] Not measured; similar to 3S sheet.

Procedure for Examination of Specimens After Exposure

Prior to the examination of the aluminum specimens in the concrete, the blocks were examined for cracks, radiating from the embedded specimens (cracks could result from the pressure of corrosion products or from differential expansion). The aluminum specimens were then removed from the various blocks, cleaned in a hot solution of phosphoric and chromic acids (ASTM-B137-45), scoured with soap impregnated steel wood pads, (S.O.S.), and carefully examined.

The condition of the dummy brick and stucco walls was noted before the aluminum specimens were removed, the specimens were then cleaned in the same way as above and examined.

TABLE 5

Relative Condition of Test Specimens (Ten Years' Exposure)

Best:	Brick mortar pier	(atmospheric)
	Stucco wall sections	(atmospheric)
	Concrete blocks	(dry)
	Concrete blocks	(atmospheric)
	Concrete blocks	(wet soil)
	Concrete blocks	(water tank immersion)
Worst:	Concrete blocks	(Lake Ontario immersion)

TABLE 6

Effect of Source of Supply of Cement on ALCAN 3S Specimens Embedded in 1:3:3 Concrete Exposed to the Atmosphere for Ten Years

Source of Cement	*Type of Cement*	*Per cent Soluble Alkalies*[1]	*Condition of Blocks*[2]	*Per cent Weight Loss* 10 yr.	1 yr.	*Thickness of Metal Specimen Corroded (mils)*[3]
Canada Cement Co.						
Hull, Que.	Portland	0.4	C	5.03	2.60	3.5
Belleville, Ont.	"	0.5	—	—	9.80	—
Exshaw, Alta.	"	0.4	NC	1.82	1.45	0.5
Montreal, Que.	"	0.3	C	5.53	6.08	4.5
Port Colborne, Ont.	"	0.4	NC	1.81	1.77	1.0
Fort Whyte, Man.	"	0.6	NC	2.26	1.97	1.0
St. Mary's Cement Co.						
St. Mary's, Ont.	"	0.6	C	3.50	3.82	2.0
Medusa Cement Co.						
Paris, Ont.	"	0.5	NC	1.78	1.00	nil
British Columbia Cement Co.						
Victoria, B.C.	"	0.5	C	5.00	—	3.5
Canada Cement Co.						
Fort Whyte, Man.	High Early Strength	0.5	NC	1.58	1.20	0.5
Montreal, Que.	"	0.5	C	5.35	4.01	3.0
Port Colborne, Ont.	"	0.4	NC	1.23	1.45	nil

NOTES: [1]Soluble alkalies calculated as Na_2O
[2]NC—Not Cracked; C—Cracked
[3]Average of two specimens; total losses from both sides; determined by micrometer.

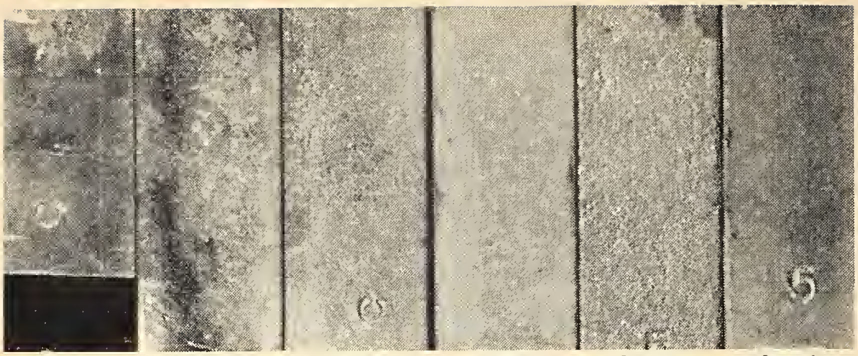


Fig. 4. ALCAN 50S Bar, Uncoated Specimens, after embedment ten years in: concrete blocks, brick mortar piers (atmospheric) and stucco wall sections and exposed as indicated.

EXPERIMENTAL RESULTS

Table 3 gives a summary of the condition of the blocks and the specimens after the 10 years' exposure in various environments while embedded in concrete, brick mortar and stucco and while subjected to limestone leaching. Figs. 2, 3, 4 and 5 show by the appearance of the specimens after exposure how the aluminum alloys performed. Table 4 presents a summary of the metal losses sustained by the specimens. All metal losses were determined by micrometer. Even in the case of completely unprotected surfaces, the attack is superficial. Bituminous paint proved to afford best protection among the coating treatments with lacquer second and zinc chromate of little or no protective value. Table 5 shows the condition of the specimens after exposure with relation to each other, ranked from "best" to "worst"; see also Figs. 4 and 5. Table 6 presents the results of the experiments to determine the effect of source of supply of the cement and Table 7 shows the effects of richness of mix. Fig. 6 shows a comparison of the per cent weight losses of the specimens embedded in concretes made with standard portland and high early strength cements after 10 years' atmospheric exposure. Fig. 7 shows the condition of specimens after embedment in concretes of increasing cement richness and exposure to the atmosphere for 10 years.

CONCLUSIONS

The 10 year results from this program confirm the findings reported[1] after evaluation of eight days', six and 18 months' results.

Aluminum alloys are not seriously corroded by embedment in concrete, standard brick-mortar, lime brick-mortar, hardwall plaster and stucco over extended periods. Slight, superficial etching takes place during the period when concretes, mortars, plasters or stucco are setting, but unless there is frequent intermittent wetting and drying, no appreciable corrosion takes place. All the aluminum alloys tested (ALCAN 3S, 50S, 65S, 57S) perform similarly. It is significant that very little difference in appearance is evident between the specimens exposed for 10 years and those exposed for 18 months and one year. The metal loss is, in no case, sufficiently great to cause deterioration of the properties of the metal in other than thin sections. In general, therefore, it may be concluded that the use of aluminum alloys is practical when embedded in the common alkaline building materials in all conditions of exposure likely to be encountered.

The observations and conclusions from this program are in agreement with those reported in a similar set of experiments by Fischer and Vosskuhler.[2] These workers observed that stifling of attack took place after one year's exposure. In the previous paper on the work at Kingston, it was reported that no appreciable change had taken place between six months and 18 months of exposure.

From the results of exposure under total immersion conditions, it can be concluded that aluminum alloys embedded in concrete and exposed in this way are only slightly attacked. The results show that specimens embedded for 10 years and kept in dry location had an etched appearance with no pits worthy of note. This etching was approximately two mils in depth. The maximum pit depth on the embedded specimens immersed in water

Fig. 5. ALCAN 50S Bar, bituminous paint coated specimens after embedment ten years in: concrete blocks, brick mortar piers and stucco wall sections and exposed as indicated.

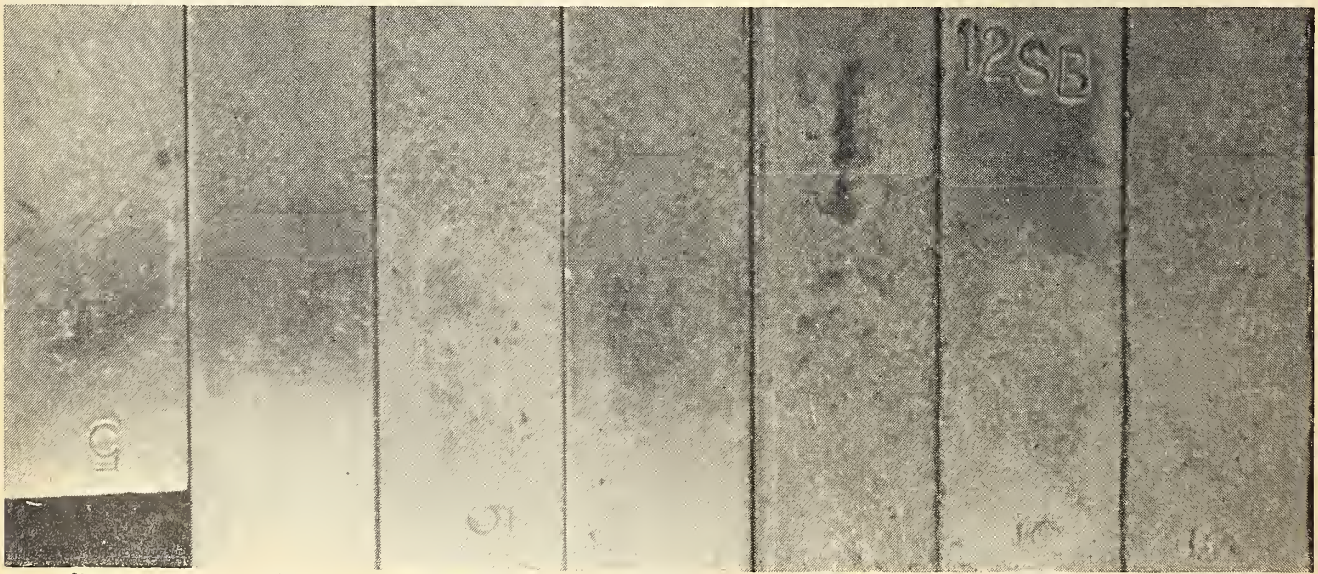


TABLE 7

Effect of Richness of Mix on ALCAN 3S Specimens Embedded in Concrete Blocks and Exposed to the Atmosphere for Ten Years

Mix	*Source of Cement*	*Per cent Soluble Alkalies*[1]	*Condition of Blocks*[2]	*Per cent Weight Loss* 10 yr.	1 yr.	*Thickness of Metal Specimen Corroded (mils)*[3]
1 : 3 : 0	Canada Cement Co.,	0.3	C	10.91	11.12	8.0
1 : 2 : 1	Montreal		C	13.29	10.86	11.5
1 : 3 : 3			C	5.53	6.08	4.5
1 : 2 : 4			C	6.13	4.88	4.0
1 : 3 : 5			NC	4.72	3.18	3.0
1 : 3 : 0	St. Mary's Cement,	0.6	C	6.89	6.58	4.0
1 : 2 : 1	St. Mary's, Ont.		C	6.14	4.98	3.5
1 : 3 : 3			C	3.50	3.82	2.0
1 : 2 : 4			C	3.30	3.08	1.0
1 : 3 : 5			NC	2.18	2.01	nil

NOTES: [1]Soluble alkalies calculated as Na_2O
[2]NC—Not Cracked; C—Cracked
[3]Average of two specimens; total losses for both sides; determined by micrometer.

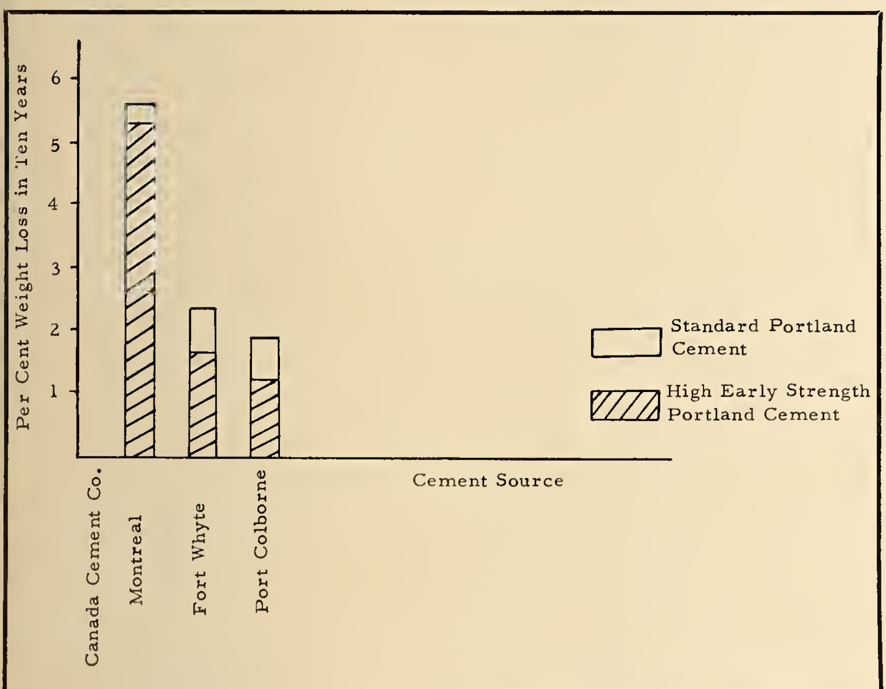


Fig. 6. Comparison weight losses of Specimens embedded in concrete made with high early strength and standard Portland cements.

for ten years was eight mils. Additional confirmation has been provided by Walton, McGeary and Englehart[3] who studied the effect of moisture on uncoated aluminum embedded in concrete. Their program lasted for six months and aluminum specimens embedded in concrete and kept in a dry location had a maximum pit depth of 1.2 mils while those which had been totally immersed had a maximum pit depth of 4.1 mils.

From the results of the experiments with concrete mixes made up from cement obtained from different sources and from the results of the experiments in which the mix was enriched by added increasing amounts of cement (variation in alkali content), it can be concluded that the amount of attack increases in direct proportion to an increase in free alkali content. In atmospheric exposure this is not serious and, in fact, nearly all the corrosion occurs during the setting period of the concrete and is negligible thereafter. Etching of the aluminum specimens in rich mixes is greater and for this reason the tendency to cracking is greater.

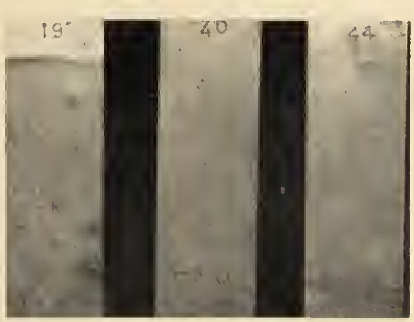


Fig. 7. Conditions of Specimens embedded ten years in concrete of increasing cement richness.

Among the protective coatings tested, the effectiveness of a single coat of bituminous paint in preventing corrosion of aluminum embedded in various building materials has been well demonstrated by its consistently good performance over the various time periods in this program. This too has been confirmed by Fischer and Vosskuhler. Clear lacquer is less protective. Thus, where aluminum is embedded in concrete or mortar, particularly where it may be continually wet, it may be desirable to paint the surfaces with bituminous paints.

It may be well to mention the situation where aluminum is installed against concrete or brick mortar, e.g. aluminum window casements in masonry buildings, although this was not included in the present program. On the basis of considerable experience, it may be stated that this exposure condition is more corrosive than total embedment and protection of the aluminum surfaces with bituminous paints is recommended.

References

1. The Resistance of Aluminum to Some Alkaline Building Materials. T. E. Wright, H. P. Godard and I. H. Jenks. The Engineering Journal, October 1954 pages 1250 to 1256 and 1260.
2. "Resistance of Aluminum Alloys to Mortars", E. Fischer, and H. Vosskuhler, Aluminium, Vol. 33, No. 9, pp 606-612, September 1957.
3. "Compatibility of Aluminum With Alkaline Building Products", C. J. Walton, F. L. McGeary and E. T. Englehart, Corrosion, Vol. 13, No. 12 pp 41-51, December 1957.

EIC

ENGINEERING EDUCATION

HAVE WE A PROBLEM?

W. F. McMullen,
Engineering Personnel Manager,
Canadian General Electric Company Limited

Presented at the 75th E.I.C. Annual General Meeting, Vancouver, May 1961.

IF we have a problem in Engineering Education, just what is it?

For many it seems to date from the arrival of Sputnik—but in reality, a steady change has been going on over many years. The arrival of the space age however, caused, as Professor David C. White of M.I.T. states—"the whole scientific community to publicly express the deep-seated dissatisfaction which has been felt for years, on the lack of importance placed on scientific education and thought." In a word, then, the scientific "egg-head" became a person whose opinion was worthy of consideration.

The resulting publicity and glamour seemed to be directed towards the scientist so that in the minds of the public many of the developments in the space age are attributed to the scientist, and the role of the engineer in such developments is not realized.

Perhaps we in engineering have insisted upon getting upon the scientific bandwagon without a clear reappraisal of the obligations of the engineering profession. As pointed out in the A.S.E.E. report on the Evaluation of Engineering Education, "Engineering is far from static, it is a creative profession. It has played a dominant role in building our industrial activity, in developing the principles of mass production, and in giving our people their high standard of living. The continuing growth of our knowledge of basic science has opened vast new areas to engineering endeavour and has enlarged the foundations underlying many of the existing engineering fields."

This report goes on to point out the two basic objectives of engineering education. The first of course, technically "is preparation for the performance of analysis and creative design, or of the functions of construction, production or operation where a full knowledge of the analysis and design of the structure, machine or process is essential. It also involves mastery of the fundamental scientific principles associated with any branch of engineering . . ."

The broad social goal of engineering education includes "the development of leadership, the inculcation of a deep sense of professional ethics, and the general education of the individual."

Viewing this in the light of the current focus of attention on the scientist—what is the right way for us as engineers to go? Some may say, make engineering education purely scientific—go all the way, and admit that scientists are all that are required, and that the engineer can be readily replaced by the computer and the technician.

I think we will all accept that engineering—which I am told comes from the old French and Latin word "ingenium" meaning cleverness, originally contained a good deal of art or craftsmanship. It literally meant cleverness in contriving, devising, or inventing. Engineering grew initially because people by their ingenuity and inventiveness could do things before they were understood.

The re-evaluation going on today of engineering education is resulting from the change in the scientific concepts which an engineer needs in order to deal with the new problems facing him. This change in scientific concept, perhaps far more than the change in technological pace, is the villain of the piece that prompts young engineers just out of college to say "my education was obsolete".

As Professor White further emphasizes—"in the future, engineers are going to have to understand the physical sciences in depth, and also their exploitation. This new curriculum is called engineering science because educators, for one, have not faced the fact that what they thought was engineering, is not engineering today. This is the transition stage. What is called engineering science is engineering, and it is the kind that within the next decade will have to be taught and practised in universities and industry."

So when James Zeder of Chrysler points out "we are just beginning to realize the immense size of the demands which the rapidity of technological change is making on our educational institutions," and adding "that the biggest challenge faced by the engineering educator is not that of preparing the student for today's jobs, but for the tasks of the future",

we should recognize that what we understand as engineering is changing, and that we are not merely climbing on the scientist bandwagon!

His further remarks bear out more of this same concept when he says "the hardware, plumbing and wiring in today's undergraduate engineering curricula should be reduced drastically or eliminated altogether. The four-year curriculum should not waste the student's time by teaching him specialized techniques that are certain to become obsolete. Instead, it should provide him with the scientific and engineering fundamentals that will prepare him to meet new challenges—to explore new frontiers—and to tackle new jobs."

Actually this is just what the American Society for Engineering Education did recommend back in 1955. That was the emergence of this new kind of curriculum commonly known as Engineering Science. It puts greater emphasis on the basic sciences of mathematics, physics, and chemistry, and on the engineering sciences, which include mechanics of solids, fluid mechanics, thermodynamics, transfer and rate mechanisms, electrical theory, and nature of properties of materials . . . and much less emphasis on the hardware, plumbing and wiring."

While there has been a definite trend in this direction in the curricula of some Canadian colleges, it is by no means universal, and there are definite evidences of rather strongly divergent opinions on the matter. This extends even into an industry where many are convinced that the engineering colleges have got a bit far from reality, and that they should come down to earth and reflect on the needs of our Canadian economy.

It has been pointed out that we in Canada do very little basic research and development; only 1% of GNP, (Financial Post, 28 January 1961) and only 1/3 of this by industry; and hence our need is for "practical" engineers who are primarily concerned with building things, rather than living on Cloud Nine.

It has also been stated that an engineering course in Canada has long been recognized as a good sound all-around education, and has been a prime source of management material in many industries.

The same can be said of graduates who enter sales, manufacturing, operations or maintenance.

This, I maintain is our problem. If we accept the hypothesis that what we thought was engineering is no longer engineering—then we must re-evaluate our engineering curricula.

In Canada at present there are 18 engineering colleges that will grant professional degrees in 1961. In the great majority of these colleges, students enter the engineering course with little or no concept of what engineering work is—or exactly how they will practise their profession on graduation.

In most instances they have entered engineering because of a proficiency in mathematics and sciences in high school. Few of them have even met, let alone talked to a professional engineer. Over some 13 years as a recruiter of engineering personnel—I have repeatedly asked graduating students "why did you take engineering?" I feel that most students try to give an honest answer–and it usually is that they really don't know. In many instances they decided against a course in pure science because they wanted something more practical or more active—in short they wanted to be working with *things* rather than *concepts*. They are usually uncertain how they will do this, or what really professional engineering work involves.

With students entering the profession so unprepared, there is little that the universities can do except provide a challenge and a stimulation that will encourage the student and raise his sights for the future.

All too frequently, however, because of geographical problems of summer employment, the difficulties in gaining industrial experience, and the fact that students generally must take jobs that produce the greatest number of dollars in order to finance their education, those that graduate are still confused and uncertain about the future.

Now I will readily admit that many of us in the engineering profession today probably graduated feeling the same way. However, far too many graduates today in my opinion are more interested in work that rightly belongs to the technologist or technician.

Records will show that the student who graduates with an engineering degree from a Canadian university has well above average brain power. One Canadian university points out that 45 to 48% of those who enter the engineering course will not graduate, and that only 5% of the drop-outs will be for reasons other than academic! If their high school graduation standing was below 65%, none will graduate, and only 15% will go through their course without any failures or supplementals.

I feel that we can argue that from any analysis of the world about us today, three facts emerge.

1. Discoveries are rapidly being made that contradict our formerly held scientific beliefs.

2. Discoveries are being exploited at a rate that makes obsolete many of our current engineering practices.

3. Both of these are occurring at a rate that brings about sweeping changes in technology in a short time compared to the length of an engineer's career. While this poses problems for the colleges, it also poses very real problems for industry and the profession.

Even if the engineer is acquainted with current technology—he has to be a better engineer to make use of it. There was a time when he could take comfort in the fact that even if he were not too creative, he could at least do the routine engineering work. No longer can he take refuge in the fact that he can do the routine jobs well, because these jobs can now be handled by sub-professional people or automatic machinery.

This is not yet the whole story. Impressed by its success in doing development programs on a crash basis, management has come to regard it as reasonable to expect the unreasonable.

Dean Carson of Cornell emphasized this point recently when he said "there is a very real problem involving the effective life of an engineer. Conditions are changing so rapidly that an engineer 10 years out of college may fall behind. There must be refresher courses for older engineers, otherwise industry's only alternative is to hire new young graduates who are on top of recent developments."

The problems I have mentioned spread beyond our engineering colleges into industry and the profession itself.

No other profession has as short a period of training, and probably few other professions find students so ill-prepared on entrance to their university course. Many technical societies and some high schools are making a sincere effort to provide career information, but there is a need for greater counselling in this whole area. Based on geographical considerations alone, it is an almost insurmountable task.

This leads to a further point. Is the four-year course adequate to meet today's needs? In terms of lectures and laboratory periods, the amount of time spent by the student has varied little over the past 25 years. Admittedly there have been many curriculum changes, shifts of emphasis, and improved teaching tech-

niques, but it seems impossible to imagine—even if we admit that the present generation is smarter than we were—that the fantastic changes over this same period could be added to the curriculum in the same period and term structure.

If the engineering course is to be lengthened, how is it to be done? There are many proponents of the five year post-senior matriculation course, but there are differences as to whether this extra year should be pre-engineering or post-graduate. One solution, such as lengthening the terms as is common in British and European Universities, is not too popular in Canada. The principal argument is that undergraduates need the longer vacation to earn their fees. This argument is undoubtedly true at present, but it is not a reason of which we as Canadians should be proud, since our aid to students falls well below that of most other civilized countries.

Those who favor the pre-engineering year suggest it be used for cultural subjects as well as basic mathematics. In short some feel it should be used to take up the slack out of the high schools and prepare students for the way ahead. In many respects this is true, and many of the shortcomings of which engineering students are accused such as poor grammar, spelling and ability to write essays, are due to the failure of the high schools rather than to any university courses. Perhaps we can save valuable teaching time by thrusting back down into the high schools, much of the basic "readin', 'ritin' and 'rithmetic."

Since our present concept appears to be that the undergraduate engineering curriculum consists essentially of mathematics, basic scientific principles, analysis and synthesis and emphasis on the orderly presentation and handling of scientific data, it cannot provide detailed knowledge in any field. Hence the now apparent necessity of post-graduate work in many areas. The fifth (or more) years should be the post-graduate years. This approach too has much in its favor. The value of post-graduate work in many of the newer fields such as feed-back control systems and heat transfer cannot be overlooked, and equally important is the value of such work to the university itself, in terms of a vigorous outlook and attracting high calibre staff.

There is evidence of a general improvement in the number of graduates going on for post-graduate work; some directly on graduation, and some after industrial experience. In the Session 1955-56 there were 290 students registered in the engineering graduate schools (76 Doctors, 214 Masters), while in Session 1960-61 there were 721 (132 Doctors, 589 Masters).

Traditionally, certain fields of engineering have attracted more students into the graduate schools, and based on a comparison of the 1960-61 session it is apparent that the fields of chemical and metallurgical engineering lead by a wide margin.

	Graduating in 1961			Post-Graduates
	Bachelors	*Doctors*	*Masters*	*Percent*
Metallurgical	62	9	35	71.0
Chemical	258	23	55	30.0
Electrical	644	6	99	16.3
Mechanical	508	5	74	15.5
Civil	779	7	107	14.65

(NRC December 1960)

We have always needed and profited by better education for our people but the need for continued education is a more recent problem. Most students graduating in engineering are uninterested in further post-graduate study—and this includes many in the top levels of their classes academically. For some the reason is financial, for others an uncertainty of their future work or complete lack of knowledge as to just what their engineering work entails. Still others believe or have been told that they are academically incapable of such work.

Therefore, it could be argued that an additional year added to the present engineering course would not really produce a much better result than our present system, but might have the effect of introducing an even higher wastage of manpower through failure to complete the course. What appears to be needed is better communication of industrial and national requirements back to the engineering undergraduate along with even more financial post-graduate assistance, to encourage the capable students to continue into post-graduate schools.

With the present crowded undergraduate curriculum it is difficult to imagine how further training in humanities, ethics, professional attitudes can be introduced.

Engineering undergraduates have been traditionally rather "different" in comparison with the rest of the population. Individually they are the same of course, but collectively they are inclined to remain apart from the intellectual life of the university and devote their energies to the more boisterous college activities.

Most engineering undergraduates spend about 30 hours each week in lectures, laboratory and problem periods. The very minimum study time each week is an additional 20 hours, and this will vary with the individual. If very much travel to and from class is involved, the student will find it hard to take on very much extra-curricular activity unless he is outstanding. This may be a reason that so little of the apparent cultural value of a university "rubs off" on engineers!

Since the great majority of engineering graduates will work in Canadian industry, and since their working life in industry will be long in comparison to the period in university, the problem of engineering education is not only that of the universities; but there is an equal obligation on industry and *the individual engineer*.

Our engineering schools have, in my opinion, fulfilled their obligation if they have taught the basic engineering and scientific principles and trained the graduate to continue to grow and think independently.

It is the obligation of industry to provide the climate for growth, and where necessary, the tools. Experience alone is not necessarily the best teacher; it is the slowest, and very likely the most expensive. Ten years of experience is not too valuable if it is one year of experience repeated 10 times.

The other obligation is that of the individual engineer. The best development is self-development. Unless the new graduate is prepared to grow himself not only technically, but also in the humanities, business, economics and other fields—there is no other way.

So we see that the problems are not simple, or even clear. I feel at times that I have committed one of the gravest of engineering errors—in not defining the problem. But it is difficult in Canada to see our problem clearly—because of geographical and economic limitations. From my own experience I know that the universities will welcome constructive suggestions from industry as well as from professional and technical societies.

It is not a matter of a tug-of-war between the traditionalists and radicals in the matter of engineering education. It is the very real problem of being ready for the future.

Saskatoon
SEWAGE STABILIZATION PONDS

D. R. Stanley,
Consulting Engineer, Stanley, Grimble, Roblin Ltd., Edmonton

E. J. Cole,
City Engineer, City of Saskatoon

Presented at the 75th E.I.C. Annual General Meeting, Vancouver, May 1961.

MANY OF our Canadian communities have reached the saturation point respecting industrial development. Others, like that of Saskatoon stand upon the brink of becoming an industrial centre, and there are still others that are fast becoming leaders in the industrial field. Industries, it must be stated, are recognized as the major contributors to difficult sewage problems. It further seems appropriate to present this paper since the Federal Government, in recent months, has taken steps to financially assist in sewage treatment and thus to encourage plant construction in order to reduce the ever-growing problem of stream and soil pollution.

The City of Saskatoon is situated on the South Saskatchewan River. The present population is approximately 95,000. Measured stream flow conditions at Saskatoon have been as low as 500 c.f.s. and as high as 148,000 c.f.s. The Royal Commission on the South Saskatchewan River Project established the average mean monthly flow at 5,000 c.f.s. The aspect of stream flow, of course, will change sharply after completion of the South Saskatchewan River Dam. The quantity of sanitary sewer effluent now passing into the river has been determined to be 30 c.f.s. peak daily. These figures, of course, give rise to investigations to determine whether it is now necessary for the City of Saskatoon to install sewage treatment facilities. At the time of writing this paper approximately 85% of all sanitary sewage received "preparatory treatment" by being passed through a comminution station. The remaining 15% was passed directly into the stream without any form of treatment.

On March 19th, 1942, the City of Saskatoon was served with an injunction by the adjoining rural municipality requiring that "the sewage be sufficiently purified and deodorized so as to remove and avoid all menace to the public health and so as not to be or create a nuisance." Since that time steps have been taken to comminute all the sewage. This involved the construction of "collector" systems in order to direct the effluent into a main interceptor.

The City of Saskatoon has been in the enviable position of being so located that no town, factory, or industry uses the water downstream to its confluence. With the doubling of population in the past 10 years; a surge toward industrial growth; the growing consciousness of stream pollution, a recognition of the riparian rights of others and the encourage-

FIG. I
CITY OF SASKATOON
SEWAGE FLOWS WITH COINCIDENT QUALITIES
(AT COMMINUTOR STATION)

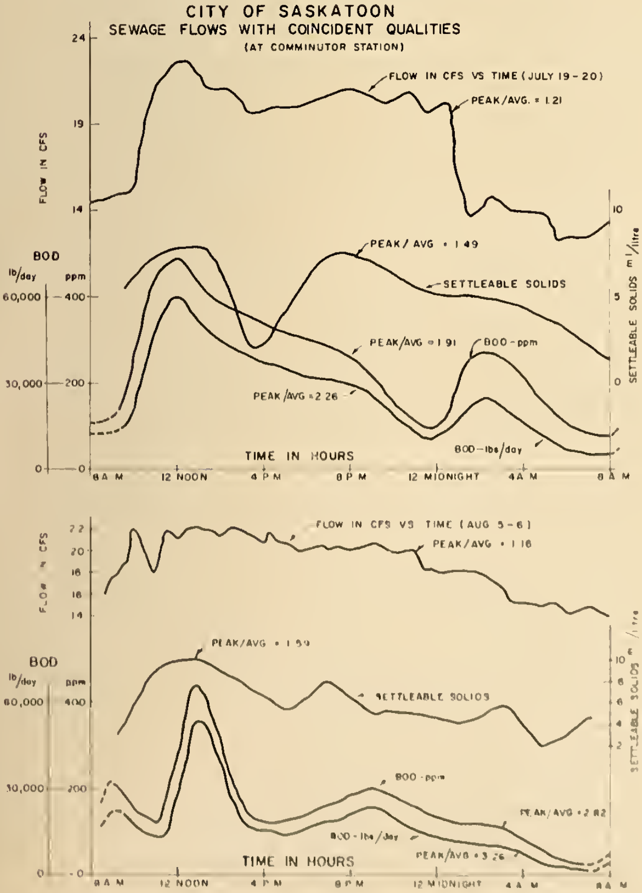


FIG. II
CITY OF SASKATOON
FLOWS AT COMMINUTOR STATION — SPADINA CRESCENT

ment being received from the senior governments it has been necessary to take a second look at present and future needs for sewage treatment.

Klein in his book, Aspects of River Pollution, (Butterworths Scientific Publications 1957), states:

"It has however long been laid down by the courts that what matters is what goes into the stream not the condition of the stream into which it goes and the offence is to add something which would pollute the stream if its waters were pure."

"Certain rights exist at common law which affect the pollution of rivers. These relate or attach to the land through which a stream flows. The right to a flow of pure water is a natural right of property and a riparian owner on a natural stream having a right to that stream in a natural state has the right of action if the water is polluted, even though in fact he sustains no actual damage. It makes no difference to his rights against one pollutor that the river is also polluted from other sources."

On the other hand there are those who claim that not only should our rivers, streams and lakes become a means of providing drinking and industrial water but also that it is one's privilege, to a degree, to use these facilities for the deposition of sewage and industrial wastes.

These natural resources, however, cannot be used indiscriminantly for repositories for the disposal of untreated wastes on the one hand and sources of drinking water on the other hand. To be practical it must be realized that we cannot economically avoid a degree of water pollution. To those who administer to the needs of our communities must fall the responsibility of providing the maximum benefit to the maximum populace, without infringing on the rights of the individual.

The City of Saskatoon for many years has been asking the question: "To what extent can we permit our stream to be used as a vehicle to dispose of wastes?" The answer is now being sought by taking the initial step towards the construction of treatment facilities.

Objectives of Sewage Treatment

The objectives of sewage treatment are the avoidance of nuisance and danger to health arising from the discharge of untreated sewage. There are many criteria of pollution of streams and lakes by sewage and industrial waste. Four of common ones are:

(1) Oxygen depletion
(2) Suspended Solids
(3) Grease
(4) Coliform Density

Depletion of oxygen: The condition of organic matter discharged with sewage or industrial waste into a lake or stream is intimately associated with the availability of oxygen. In the decomposition process of sewage, oxygen is consumed by the organisms which in turn produce carbon dioxide and certain nitrogen gases. If the dissolved oxygen content in a lake or stream is maintained and other conditions are conducive to the growth of the lowest form of organisms then all forms of life in the streams will flourish. If a depletion of the dissolved oxygen occurs to too great an extent the higher forms of life will be affected seriously and may succumb, resulting in a serious change in the mode of life.

In the absence of oxygen the aerobic organisms disappear and anaerobic organisms develop. The anaerobes exist in the absence of free oxygen but in their metabolism use oxygen from other constituent elements in the water such as nitrogen and sulphur compounds. The result is often a septic condition, with foul appearance and obnoxious odours. Too high a demand on the receiving water for oxygen by the organic matter in the sewage or waste may result in complete depletion of oxygen and the conditions referred to above. With either aerobic or anaerobie decomposition, the ultimate products are mineral and stable organic materials. These have the appearance and the odour of earth. For the sake of visual and olfactory aesthetics the decomposition of sewage should be accomplished in waters having sufficient oxygen.

There is a relationship between the normal maximum saturation amount of dissolved oxygen in water and its temperature. For example, cold water can retain more oxygen than warm. Water may be supersaturated with oxygen by agitation with air such as may occur in a rapids area. Dissolved oxygen content will increase where a release of oxygen by aquatic plants is encouraged by the influence of sunlight.

A demand by organisms for oxygen may diminish the dissolved oxygen below the saturation value. This demand for oxygen is termed biochemical oxygen demand (B.O.D.). In order that organisms may continue to exist, a supply of oxygen must be replenished normally. This is done from the atmosphere or by photosynthetic organisms, but may be artificially introduced by chemicals or by oxygen gas.

The rate of transfer of oxygen between the atmosphere and the body of water in question will vary with many factors, such as the depletion of oxygen below its saturation in the water, the area exposed to the atmosphere, and the nature of the surface of the water. If being agitated such as in a rapids area of a stream, the transfer will be more rapid, whereas on a quiet lake the transfer may be very slow. With an interposed sheet of ice, there may be no transfer of oxygen at all. Tests on various streams have made it possible to formulate the various factors involved in determining the probable depletion of oxygen in a stream by correlating the effect of the known sewage strength (oxygen demand) and the ability of the stream to supply oxygen to meet this demand.

Suspended Solids: When sewage or industrial waste containing a high concentration of suspended solids is discharged into streams or lakes, the solids may settle out and form sludge beds in the slower reaches of the

Table I

Results of Analyses on Raw Sewage from Comminutor Station

No.	*Day*	*Total Solids ppm*	*Suspended Solids ppm*	*Volatile Suspended Solids ppm*	*5-Day BOD ppm*	*Grease ppm*	*Settleable Solids cc/litre*	*COD ppm*	*pH*	*Alkalinity ppm*
1	Tues. May 26/59	1030	270	218	210	49	5.0	—	7.6	—
2	Tues. June 16/59	966	438	340	270	111	6.5	—	7.3	—
3	Mon. June 22/59	1054	460	324	260	77	4.5	—	7.2	—
4	Tues. July 19/60	1090	200	160	250	75	4.5	340	7.0	184
5	Fri. Aug. 5/60	930	300	140	175	83	5.3	145	7.8	213
6	Mon. Aug. 8/60	740	240	120	142	90	5.1	670	8.1	205
7	Wed. Aug. 10/60	750	200	110	295	82	4.8	440	7.2	232
8	Thurs. Aug. 11/60	870	210	150	190	75	7.0	580	7.0	207
9	Fri. Aug. 12/60	—	160	120	300	70	5.0	42?	7.4	530

receiving body of water. These deposits forming on the bottom of streams and lakes may interfere with the natural life existing therein and can give off obnoxious gases and scum formed by the anaerobic decomposition of the organic matter in the deposits.

Grease: An excessive amount of grease discharged in lakes or streams floats on the surface but eventually find its way to the shore line and coats the bank, thus creating unsightly conditions.

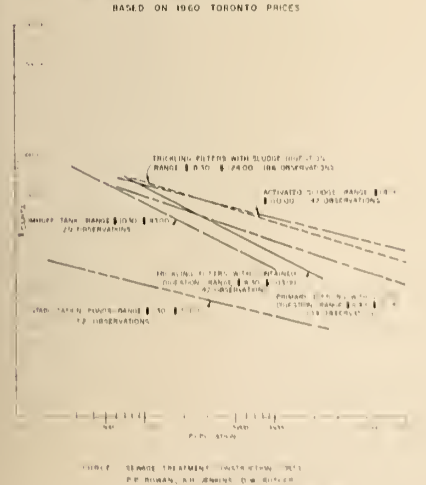
Coliform Density: Sewage contains organisms which can cause illness and disease. The coliform group of bacteria are relatively harmless in themselves, but it is generally considered that where coliforms are present, pathogenic (disease producing) bacteria may also be present. Since it is not too difficult to determine presence of coliform organisms and their approximate density, the density of them is used as a measure of the degree of pollution.

Quality of the River Water

Systematie analyses of the South Saskatchewan River water carried out by the Department of Public Health and the Provincial Department of Natural Resources indicated a high level of dissolved oxygen at all times. The lowest level occurred usually in mid-summer with a minimum of 7.8 milligrams per litre or 86% saturation. One test taken in mid-winter showed 9 milligrams per litre or 66% saturation. Water temperatures from late October to late April were an average minimum of 33° F. In the other six months the average temperature was usually 66° F. with the recorded maximum of 75° F. Examination of the river downstream from Saskatoon did not indicate the formation of any sludge banks.

On the basis of the surveys carried out, there appeared to be little indication of serious pollution of the stream, although the report of the Department of Natural Resources indicated some apprehension. However some regulatory authorities have adopted the policy that no sewage or waste should be discharged into a stream or lake without at least primary treatment. The other factor, however, that is quite important in Saskatoon is the injunction served by a Municipal District requiring the city not to dispose of untreated sewage in the river. Regardless of what the Health authorities might accept as stream sanitation standards, there is always the danger that a downstream user may take court action and obtain damages or the requirement for the City to treat its sewage. Thus consideration of the problem at this time is certainly justified.

FIG. III
CITY OF SASKATOON
PER CAPITA COSTS OF VARIOUS SEWAGE TREATMENT METHODS
BASED ON 1960 TORONTO PRICES



Quality of Sewage

As with a stream there are many crietria which are used to describe the quality of sewage and industrial waste. Three of the most common for domestic sewage are:

(1) B.O.D.
(2) Suspended Solids
(3) Grease

The B.O.D. test is the most common test used to determine the amount and nature of organic material in the sewage. However, other tests such as ammoniacle and organic hydrogen, permanganate oxygen adsorption, and oxygen taken up by potassium dichromate are also used and have application under specific conditions. For example the C.O.D. test is a determination of oxygen consumed from potassium dichromate. It is used quite extensively in testing certain inhibatory trade wastes. Among the important factors which determine the strength of sewage, are the type of sewage (i.e. combined, separate, or partially separate) amount of infiltration water, the daily water consumption per capita, the food and other habits of the population, and the amount and character of industrial wastes present. Samples of raw sewage were taken at the city's comminution station and the results of analyses shown in Table 1. The first test result shown below was a composite of four hour samples; test results two and three were composites of three hour samples; the remainder of the results were obtained generally from 2-cup grab samples taken every half hour. All represent 24 hour composites.

It is difficult to establish a correlation between BOD and COD from the above results.

Fig. 1 shows the variation in flow BOD and suspended solids for July 19 and August 5, 1960. Also plotted is the variation in the total BOD loading. For July 19 the total BOD was 25,090 lbs. in a total flow of 10 million imp. gal. or an average BOD of 251 ppm. This compares to the BOD on the composite sample for the same day of 250 ppm. For August 5 the corresponding figures are 16,200 lb. BOD in 10.3 million imp. gal. or 158 ppm. The composite for this day tested at 175 ppm.

Sewage Flows

We have not as yet carried out a thorough analysis of the characteristics of sewage flows in Saskatoon. Fig. 2 shows the results of some measurements taken at the comminutor station. Where design flows were needed to analyse the sewage treatment problem estimated flows presented in a report by Underwood McLellan & Associates Ltd. were used.

Sewage Treatment and Disposal

There are many conventional methods used for the treatment and disposal of sewage. These can be broken down in general as follows:

(1) Disposal by dilution
(2) Primary treatment
(3) Complete treatment

Another more recent method, the use of sewage stabilization ponds will be considered in a following section.

Disposal by Dilution: Much pollution and fouling of streams has been caused in the past by the uncontrolled discharge of raw sewage into streams. Nevertheless, subject to certain safeguards the method of disposal by dilution may be used with satisfactory results. The chief limiting factor in many cases is the capacity of the stream to supply oxygen to meet the oxygen demand of the sewage or waste, without reducing the oxygen content in the stream to below a safe level. Other factors, of course, are whether or not the sewage solids will form sludge banks that are obnoxious or grease will give trouble along the banks of the stream or the solids may be unsightly. The problem of unsightly solids is very often handled by putting in sewage grinders or comminutors to grind the sewage before discharging it to the stream. In the case of Saskatoon the South Saskatchewan River has a large enough flow so that the oxygen demand of the City sewage does not deplete the oxygen in the River to any dangerous degree. Also, the comminutor station has been successful in eliminating most of the nuisance that might otherwise have existed from objectionable floating solids. The comminutor plant was installed in Saskatoon about 1942.

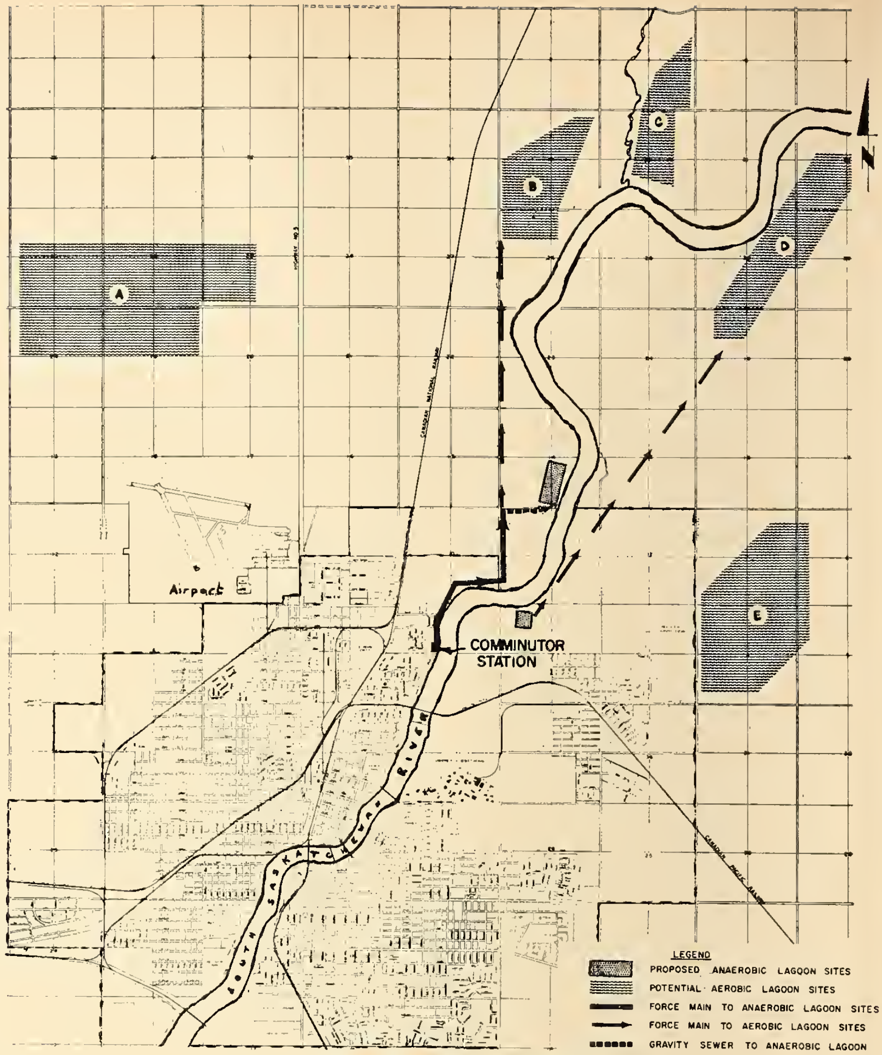


Fig. 4. Overall plan — Saskatoon Area

Primary Treatment: Primary treatment is usually accomplished by allowing solids to settle out of the sewage in a sedimentation tank. Primary treatment facilities may include one or a combination of the following: rakes, screens, comminutors (these grind coarse matter), skimming tanks, grit chambers, settling tanks with manual or mechanical solids removal, chemical precipitation tanks, septic tanks, Imhoff tanks.

Sludge thus removed is treated separately by methods such as:

i. Digestion (anaerobic biological process) in heated or unheated tanks. After digestion, sludge may be treated by such procedures as drying on drying beds, mechanical filtration or incineration.

ii. Mechanical filtration of raw sludge.

iii. Incineration of raw sludge.

Secondary Treatment: This involves the treatment of primary effluent using an aerobic biological process, accomplished by the use of either the activated sludge or the trickling filter process. The trickling filter process utilizes a bed of crushed stone or gravel over which sewage is sprayed. The sewage passing through the rock bed carries air along and is treated as it contacts a film which adheres to the stones. The organisms living in the film digest and liquefy the organic matter dissolved or suspended in the sewage. Because of the continuous passage of air through the filter bed, this process is an aerobic one.

Fine particles are contained in the sewage effluent and these are settled out in a final sedimentation tank. The effluent from the secondary sedimentation tank should be clear and inoffensive.

In the activated sludge process, the effluent from primary sedimentation tanks flows into a tank into which air is introduced by bubbling or by mechanical agitation. Sludge which has been through the process and has become "activated" by this air is mixed with incoming sewage. The introduction of activated sludge is considered to be a seeding process, increasing the growth of aerobic bacteria of the species which are most effective in the digestion of the organic material in the sewage reaching the aeration tank.

The effluent from the aeration tank is passed through secondary sedimentation tanks where the suspended matter is settled out. This settled sludge is the activated sludge. Effluent from the secondary sedimentation tank should be clear and inoffensive. A combination of primary and secondary treatment is called complete treatment.

Sewage Stabilization Ponds

During the past few years the terms sewage lagoons, oxidation ponds, and stabilization ponds have often been used interchangeably. This practice has led to some confusion.

About 13 years ago, when the State Health Department in North Dakota became interested in the use of open ponds for the treatment of raw sewage, such ponds became generally known as sewage lagoons. The term was normally reserved for ponds used for treating raw sewage. At the same time, and previously, there were, of course, many ponds which were used to treat either primary or secondary sewage effluent. These ponds were normally called oxidation ponds.

When the U.S. Public Health Service became interested in the examination of lagoons in North and South Dakota, the confusion in terms was recognized and the term waste stabilization pond was brought into use.

Towne and Davis[1] define a waste stabilization pond as a structure specifically designed to treat liquid organic wastes by biological, chemical and physical processes commonly referred to as natural self-purification. Thus, for the purpose of this paper, the term stabilization pond will be used to include both aerobic and anaerobic lagoons, and oxidation ponds.

Sewage ponds have been utilized in Asia for centuries, but our earliest available data regarding them came from various parts of Germany where valuable crops of fish were grown in sewage ponds.[2]

More than 50 years ago sewage stabilization by photosynthesis was utilized in the southwestern part of the U.S. The city of San Antonio employed this principle in 1901. The use of what are known as oxidation ponds to obtain secondary treatment of sewage appeared in California in 1924. Until about 12 years ago, the main application of such ponds was for the final treatment of effluent before disposal.

The City of Fessenden in North Dakota has discharged raw sewage into a slough west of the city since 1928. This slough has been diked,

and to date has provided adequate treatment. However, the first deliberately designed lagoon in North Dakota was constructed at Maddock in 1949, and as a result of observations of it, the North Dakota State Health Department endorsed the use of similar facilities for the treatment of raw sewage from many municipalities in that state. In 1955, the U.S. Public Health Service started a survey of lagoons in North and South Dakota and concluded that they were an effective and economical answer to treatment and disposal problems.

It is interesting to note[3] that in 1940, before the North Dakota Health Department became interested in this method of sewage treatment experiments were conducted in Melbourne, Australia, to determine the purifying capacity of lagoons. Primary treatment was accomplished by the use of relatively small lagoons which, because of their size and high loading, remained anaerobic at all times. Secondary ponds were aerobic. These experiments have been carried on since and further results reported.[4]

The general practice for the treatment of municipal sewage in the northern plains area of the U.S. and in Western Canada has been to utilize only aerobic lagoons. In most cases this has involved the discharge of raw sewage into a single pond in which complete treatment is accomplished. The retention periods and surface areas of such ponds were considerably greater than were followed in practice with the oxidation ponds used in the southwestern United States.

The lagooning of canning wastes has been practiced for many years and the organic loadings were so high that anaerobic conditions prevailed. Stabilization ponds have been deliberately designed for anaerobic operation in Australia for sewage from the City of Melbourne,[3,4] in New Zealand,[5] and the U.S.A. for packing house waste and in Alberta for sewage from many small communities. Results to date, although meagre, indicate great possibilities for this method of treatment.

Aerobic Stabilization Ponds

The process of sewage treatment by the utilization of aerobic stabilization ponds is essentially that of discharging raw sewage into an open pond which has sufficient capacity to provide a certain desired retention period, and a large enough area to assure that aerobic conditions are maintained. Sewage after retention is disposed of in one or more of three ways, namely: percolation into the soil, evaporation, and overflow.

Standard types of modern sewage treatment plants simply provide facilities in which natural, physical and biological purification processes are utilized in a very small space under controlled conditions. In nature these processes are in operation at all times in lakes, ponds, and streams. In a sewage treatment plant their rates of reaction are increased tremendously, thus allowing concentration into a small space. Because of this relatively high rate of reaction, especially in biological treatment, the operation of the plant can easily be upset and therefore has to be controlled by skilled operators. The aerobic stabilization pond provides primary and secondary treatment similar to that of a complete sewage treatment plant.

In an aerobic sewage pond the area is large enough to allow absorption into the water of oxygen to supply the oxygen demand of the sewage. In addition, to the transfer from the atmosphere a major source of oxygen is from the growth of photosynthetic organisms primarily algae. These organisms consume carbon dioxide and produce oxygen. In the summer the ponds usually have very heavy growths of algae and become supersaturated with oxygen. During colder weather the concentration of these organisms is reduced and a smaller amount of oxygen is supplied for photosynthesis. The effect of photosynthesis, however, may carry on well into the winter months.

The design of an aerobic stabilization pond must be such that the required surface area is provided and the shape and depth properly proportioned to assure good circulation. Circulation is necessary to supply oxygen at all locations where it is needed.

Treatment facilities can be provided in a single pond or in more than one in series or parallel. Series operation will cut down short circuiting. Experience with this type of arrangement indicates that it is preferable to a single pond especially where the reduction of coliform density is an important factor. The percentage reduction of coliform density is very high in aerobic ponds.

Sewage is usually discharged in about the centre of the pond or where series operation is utilized, in the centre of the primary pond. The purpose of this commonly accepted practice is to assure that the B.O.D. load which is initially applied gets the benefit of the best circulation and therefore the maximum supply of oxygen. Also, it provides the least chance of sludge beds forming to the extent that they will protrude above the surface of the sewage.

A limiting factor in design is that of winter operation during which times the concentration of photosynthetic organisms is decreased with the resulting reduction in available oxygen supply. In addition, ice cover practically eliminates the transfer of oxygen from the atmosphere to the sewage. After the onset of winter there is progressive decrease in the concentration of oxygen in the ponds and in the efficiency of treatment. However, a limited number of observations on lagoons indicate that the efficiency of treatment stays up to over 90% even in January. The minimum efficiency usually occurs just prior to break-up at which time as low as 65% B.O.D. removal has been observed. This is still equivalent to intermediate treatment and such conditions exist only for a short period of time. In many cases, it is economical to provide sufficient storage to allow the overflow of sewage to be stopped at times when the efficiency of treatment is too low.

Fig. 3 shows a comparison of costs of aerobic stabilization ponds with other methods of treatment. The information for this figure was obtained from an article entitled "Sewage Treatment Construction Costs", by P. P. Rowan, K. H. Jenkins and D. W. Butler, which appeared in the June 1960 Journal Water Pollution Control Federation. The costs were converted from 1913 dollars to 1960 Toronto dollars, by means of the Engineering News Record Construction Index.

The costs for stabilization ponds do not include the outfall line, or any pumping facilities, but do include any piping and appurtenances within the limits of the earth dikes.

Anaerobic Stabilization Ponds

The most common and long established type of anaerobic treatment is accomplished in the septic tank. Septic tanks at one time were used quite frequently for the treatment of municipal waste. However, very few of them have been built for this purpose in recent years. Coulter et al.[6] carried out laboratory experiments and later[7] pilot plant tests on an anaerobic contact process for the treatment of domestic waste. Additional tests on the pilot plant were reported later.[8] The purpose of these experiments was to find a low cost method of treating sewage for small subdivisions.

With the anaerobic contact unit of the laboratory set up operating with a one-day detention period B.O.D. removal ranged from 53 to 78% (Average 67%) at 4°C. and at room

temperatures averaged 81%. No odour nuisance was evident in the laboratory tests.

A pilot plant was constructed and the main part of it, the sludge contact unit, consisted of a cone-shaped container into which the sewage was discharged at the bottom, allowed to percolate up through a sludge blanket and decanted off the top in a similar manner to a solids contact water treatment unit. Raw sewage in effect, passed through a concentrated suspension of anaerobic activated sludge. The detention period in this contact unit was less than 24 hours. From November to March (mean Air Temperature less than 3.5°C) C.O.D. removal averaged 54% and suspended solids removal 74%. From April to July the corresponding removals were 77% and 88%. There was some hydrogen sulphide production but not in offensive quantities.

The essential difference between the anaerobic contact unit and a conventional septic tank is that the anaerobic contact unit had a cone-shaped bottom and the raw sewage was brought into intimate contact with anaerobic sludge which had been in the unit for quite some time. In a septic tank the raw sewage comes in at the top and leaves at the top and the greatest anaerobic activity takes place in the sludge in the bottom of the tank and not intimately connected with the raw sewage passing through the tank. Schroepfer et al[6] used anaerobic tanks to treat packing house wastes but with temperatures maintained of about 95°F.

Anaerobic lagoons were used successfully by Parker et al[3,4] in Australia, in 1940. Their ponds were 3 ft. deep and the loadings were quoted on an aerial basis. Table II shows some of removal rates obtained with these anaerobic lagoons.

Table II

BOD Reductions During Anaerobic Treatment

**Detention Time Days*	*B.O.D. Removal lb./acre/day*
1	1862
2½	900
5	470
10	240

**Average water depth was 3 ft.*

In these experiments sewage from the City of Melbourne was treated in anaerobic lagoons followed by aerobic lagoons. Sludge accumulation was held to be beneficial to the process. The odours from the anaerobic ponds were negligible once alkaline fermentation was established in the settled sludge.

It is our opinion that anaerobic ponds should be deeper than 3 ft., and, the deeper they are the better. In experiments carried out by Coulter et al,[6,7,8] it would appear that a vertical column in which the raw sewage was passed up through a suspension of activated anaerobic sludge would produce the best results. This may be practical for a plant where the contact unit is constructed of steel or concrete but where ponds are built with earth, area and depth relationships are limited. Earthwork ponds should probably be as deep as is consistent with economical construction.

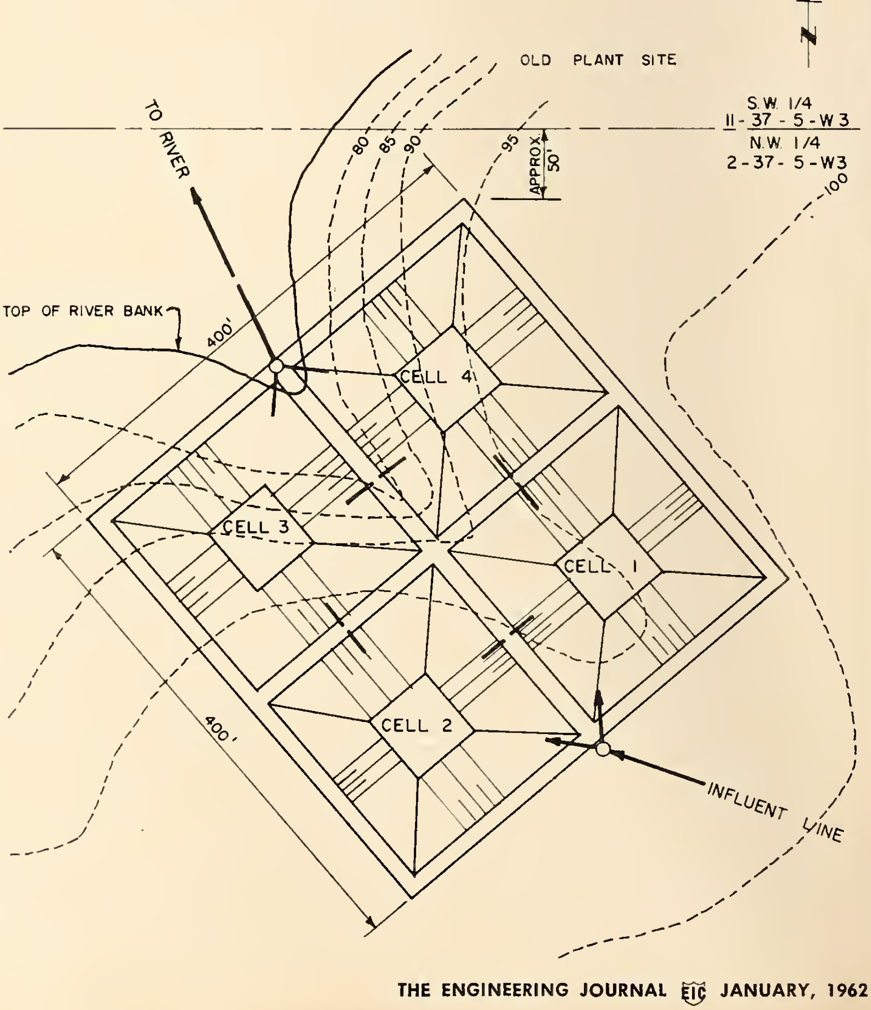
It is recommended that the sewage inlet be at the very bottom so that the raw sewage can become intimately associated with the activated anaerobic sludge. In Parker's work, the loadings are shown on a basis of lb./acre/day. It is probable that if the ponds had been 9 ft. deep instead of three, but with one third of the area the removal figures would have been three times those given in Table II. The figures in Table II indicate that most of the work is done in one day.

There are several anaerobic stabilization ponds treating sewage from small communities in Alberta. One of these for the Town of Stony Plain (Pop. 1100) has three ponds operated in series. The Alberta Health Department has reported a greater than 30% BOD removal in each of these three ponds where the total detention period is about nine or 10 days, the total removal being about 70% in the winter and about 75% in the summer. The significant factor was that each pond appeared to remove about the same percentage of the BOD applied to it. This appears to be inconsistent with the results obtained by Parker et al in Australia, where according to Table II one day detention produced almost as must removal as 2½, five and 10 day detention times. For example, the ten day detention period removed 2400 lb./acre in 10 days whereas the one day detention time removed 1862 lb./acre/day. However Parker et al[4] report BOD removals as high as 87% at a detention time of 2.9 days, in summer and as low as 47% with a detention time of 1.9 days in winter.

Hicks[5] has used anaerobic stabilization ponds to treat packing house waste, and reports no difficulty in obtaining 85% BOD removal with only two days' detention, keeping the temperature controlled at 70°F., and using gentle stirring in the pond. He

FIG. V

PROPOSED TEST STABILIZATION PONDS
CITY OF SASKATOON



states that aeration will not dissipate any hydrogen sulphide to the atmosphere if the pH is kept above 7.4 as it should be, since sulphur will appear as colloidal elemental sulphur. Swift and Company[10] treats presettled packing plant waste in four day detention ponds in which temperature is maintained at 70°F. Stirring is accomplished by recirculation from the pond back to the influent.

The effectiveness of anaerobic ponds in removing coliform organisms has not been too well established but they do not appear to be as efficient as aerobic stabilization ponds. Some authors[2] have reported that the removal of coliform organisms in stabilization ponds is accomplished by antagonistic organisms which develop in the ponds or toxic material that is produced by the organisms. However, others refute this point. The important factor may simply be that of natural die-away of organisms living in an unsuitable environment.

There has been too little research work done on anaerobic stabilization ponds to be certain of their applicability in all cases. If the requirements are for primary treatment of sewage or even considerably better, the anaerobic stabilization pond should be considered. There is no doubt that this method will provide adequate treatment but there is not sufficient data. yet available to assure the designer that odour nuisance will not occur. On the basis of the limited information available, it appears that odour would not be an insurmountable problem and in most cases, may not be a problem at all. To be safe, anaerobic ponds should be located in a remote place, if possible one-half mile from any built-up community.

In the Province of Alberta the Health Department is very enthusiastic about the performance of anaerobic stabilization ponds and is requiring that they be installed as pretreatment for aerobic or storage ponds. The requirements in general include the construction of four ponds so that at the outset, three or four can be operated in series and when the sludge depth in the first pond becomes too great, it can be taken out of service, allowed to rest for a certain period of time and the sludge eventually removed from it, after which it can be put back into service.

The requirements are generally that each pond should be designed for a retention period of about seven days at full supply for existing flows and as the community grows, this retention period can gradually reduce to as low as two days. In the design the level should be flexible so that the reduced detention periods can be obtained. Experience with anaerobic ponds indicates that too long a retention period may give rise to the production of offensive odours, and thus flexibility should be provided in this regard. In general, about 10 ft. of depth is considered satisfactory. However, as stated before, we feel that the greater the depth, the better the operation is likely to be.

There is much research work to be done yet on anaerobic stabilization ponds before it is possible to design them with confidence to fit specific needs. It is necessary as soon as possible to determine the effect of various design features on BOD, suspended solids, coliform and grease removal, as well as the various factors affecting odour production. This danger of odour nuisance appears to be the main thing that causes people to resist the acceptance of anaerobic stabilization ponds. Some of the factors in design that may be varied in order to determine their effect on treatment efficiency are as follows: retention period, depth of ponds, temperature, sewage strength and other characteristics of sewage quality, stirring, re-circulation.

One might consider the design of an anaerobic stabilization pond type of treatment facility including a contact unit in which a high concentration of activated anaerobic sludge is kept gently stirred. From the second cell where the overflow from the contact unit is allowed to settle, the activated anaerobic sludge could be pumped back to the influent sewer. This type of set-up would be very similar to an activated sludge plant except that the sludge would be anaerobic. In such a facility, of course, if it were constructed in earth work, it would not be costly to provide alternate contact units so that when the sludge build-up was too great, the sewage could be diverted to the alternate contact unit and after a rest period the first unit could be cleaned out. This is essentially the method of operation adopted in Alberta.

The anaerobic stabilization pond type of treatment and the great number of possible alternatives in utilizing it show promise of providing very economical sewage treatment. Therefore, there is no doubt that it should be given serious consideration for many installations, especially where it is possible to obtain relatively remote sites within economical distances of the community.

Saskatoon is just such a situation. There is no treatment to speak of at the present time other than comminution and there is some pressure on the City to provide treatment. Anaerobic stabilization ponds are so economical in the treatment of sewage that they have been given consideration.

Sewage Treatment for Saskatoon

On the basis of present Public Health Standards it is doubtful whether the condition of the South Saskatchewan River would normally require treatment of the City sewage for some time in the future, but many Public Health authorities are adopting the policy of not allowing sewage to be dumped into streams without at least primary treatment. The other factor in the City of Saskatoon is the injunction that was served on the City in 1942 requiring them to treat sewage before disposal into the River. If this injunction is actively pursued, the City may be required to provide sewage treatment in the near future. It is, therefore, quite important that a study of the future needs for sewage treatment be made so that long range plans can be formulated to provide for it.

In making an analysis of the problem of sewage treatment for the City of Saskatoon, several different alternatives were considered. In a complete, detailed economic analysis of these various alternatives, the estimated year by year cost for the future years would have to be calculated. However, in the comparisons a more approximate approach was made and the flow conditions in 1971 were assumed to be a good basis for a reasonably representative economic comparison.

Based on a report prepared by Underwood, McLellan & Associates Ltd., a 1971 population of 140,000 was assumed, with an average sewage flow of 117 gal. per capita per day. Further studies may refine these assumptions. However, for an economic analysis at the present time, they are certainly valid. Also, it is assumed that primary treatment of sewage will be required at any time and secondary treatment will not be needed for at least 20 years. It is almost impossible to predict what the requirements of the Health Department may be, but we feel that these assumptions are reasonable. In considering the alternatives described hereunder, one should refer to Fig. 1. The alternatives studied were as follows:

Alternative 1: A conventional primary treatment plant located on a site at the present comminutor station

Alternative 2: A conventional primary treatment plant located about two miles northeast of the existing com-

minutor station but utilizing raw sludge lagoons rather than conventional sludge digestion.

Alternative 3: A conventional primary treatment plant located on a site at the present comminutor station, but utilizing raw sludge lagoons and pumping the sludge to a location about two miles northeast of the existing comminutor station.

Alternative 4: The use of aerobic stabilization ponds on both sides of the river at locations suggested in the Underwood, McLellan report.

Alternative 5: The use of aerobic ponds in one location on the west side of the river.

Alternative 6: The use of anaerobic ponds on both sides of the river.

Alternative 7: The use of anaerobic ponds, all located on the west side of the river.

Table III shown hereunder presents an economic comparison of all of the seven alternatives investigated.

Table III
Comparison of Alternative Schemes

Alternative No.	*Capital Cost*	*Annual Costs Capital & Operating*	*Cost per 1000 gal. c (1971)*	*Est. B.O.D. Removal*	*Remarks*
1	2,236,000	305,000	5.3	35%	May require secondary
2	2,221,000	334,000	5.8	35%	treatment after 20–25
3	1,568,000	228,000	3.9	35%	years.
4	2,236,000	262,000	4.5	70%—95%	Probably will not require
5	2,186,000	266,000	4.6	70%—95%	additional secondary treatment for more than 40 years.
6	1,091,000	163,000	2.8	70%—75%	Not much experience
7	1,312,000	189,000	3.3	70%—75%	with this type of treatment—only problem may be odor. Location reduces this problem.

All costs include cost of transporting sewage to treatment site and are based on 1971 estimated flows. On the basis of flows in 1961, the cost per 1,000 gal. would be about 50% higher than shown. If a surcharge were placed on the water rates to pay for sewage treatment according to alternative 7, the cost for the average home owner would be about $2.00 per year.

The costs of construction and operation as given above are primarily for the purpose of comparing the economics of various alternatives. There are many possible variations to the alternatives presented in Table III.

As can be seen from Table III, alternatives 1, 2, and 3 are relatively expensive and would provide the least efficiency in treatment. The use of aerobic stabilization ponds as in alternatives 4 and 5 would provide a very high degree of treatment. The estimates for these two alternatives are based on providing one acre of area per 100 people at the present population. This is a very conservative design where the effluent is being discharged to the river. Experience in the mid-western United States indicates that loadings up to 400 people per acre can be used without creating a nuisance, even in areas where there is ice cover in the winter. In Alberta where the requirements are for primary treatment, ponds with only three or four weeks detention have been used and seemed to remain aerobic during the summer period. The cost of aerobic stabilization ponds could probably be less if present design criteria were not so conservative. Requiring such design standards as flat bottoms can be very costly. In several instances old sloughs have worked satisfactorily as aerobic stabilization ponds. A more detailed investigation of sites for aerobic stabilization ponds may indicate that the costs as shown in Table III could be considerably reduced.

The anaerobic stabilization pond type of treatment as presented in alternatives 6 and 7 provides such a very low cost by comparison with the other alternatives that it was not considered necessary at this time to go into very much greater detail with the other methods of treatment. At the present time, the main factor encouraging the City of Saskatoon to consider treatment is pressure of the injunction referred to before. It is thought that to satisfy the people putting this pressure on the City, it might be possible to provide anaerobic treatment for the sewage that is now presently going into the river without being comminuted.

At the present time about 85% of the sewage goes through the comminution station, the location of which is shown in Fig. 4. Some raw sewage is discharged into the river from the southeast about two miles upstream from the comminutor station. However, it is possible to discharge this sewage into the main outfall sewer. The only other major discharge of sewage is from an area known as Sutherland, housing about 6,000 people and discharging sewage into the river close to the point shown in Fig. 4 for the anaerobic lagoon site on the south side of the River. Estimates of cost indicate that the stabilization pond on the south side of the River could be provided to treat sewage from Sutherland for a cost of $25,000. The proposed design of these ponds is shown in Fig. 5. The location and configuration was dictated primarily by the topography. It was desired to be able to intercept the sewage in the Sutherland outfall and discharge it by gravity into the ponds.

The ponds would be put into operation with four in series in the order as numbered. After a few years of operation cell No. 1 would be taken out of operation, allowed to rest and sludge then removed from it. In the meantime cells 2, 3 and 4 would be operated in series. No. 1 cell could later be put back into operation.

Conclusions

A preliminary study has been made of sewage treatment for the city of Saskatoon and several alternative methods of treatment considered. As a result of the studies it was concluded that anaerobic stabilization ponds would provide the most economical treatment for at least the next 20 years assuming that odour would not be a difficult problem. The experience to date indicates that odour would not create a nuisance but if it occurred, methods of controlling it were available or could be developed.

It was recommended that anaerobic stabilization ponds be constructed to treat sewage from the Sutherland area of the city and that experimental work with these facilities be used as a basis for deciding whether this type of treatment can be used in the future to treat all of the sewage from the city of Saskatoon.

References

1. Towne, W. W., and Davis, W. H. — Sewage Treatment by Raw Sewage Stabilization Ponds. Journal of the Sanitary Engineering Division ASCE August 1957, P. 1337.
2. Fitzgerald, G. P., and Rollich, G. A.— Sewage & Industrial Wastes, Vol. 30, No. 10, P. 1213 — October 1958.
3. Parker, Jones, and Taylor — Purification of Sewage in Lagoons. Sewage & Industrial Wastes, June 1950, P. 760.
4. Parker, Jones, and Greene — Performance of Large Sewage Lagoons at Melbourne, Australia. Sewage & Industrial Wastes, February, 1959, P. 133.
5. Hicks, Ronald — Chief Chemist, Auckland Metropolitan Drainage Board — by private communication.
6. Coulter et al, J.A.S.C.E., 82, SA5, 1089 (1956).
7. Coulter et al — Sewage and Industrial Wastes, Vol. 29, No. 4, April, 1957, P. 468.
8. Witherow et al, J.A.S.C.E., SA6, 1849-1, November 1958.
9. Schroepfer et al — Sewage and Industrial Wastes, Vol. 27, No. 4 (April 1955).
10. Private communication.

Discussion

WEAKNESSES OF THE THEORY OF PLASTIC DESIGN

A. Hrennikoff, M.E.I.C.
Professor of Civil Engineering,
University of British Columbia,
Vancouver

The Engineering Journal, November 1961 page 57

Discussion by Lynn S. Beedle, George C. Discoll, Jr., Thedore V. Galambos

The discussers agree with Prof. Hrennikoff in that the principal problems requiring solution before the plastic theory could be applied were those involving inelastic instability. The discussers, however, disagree with his conclusions wherein he pessimistically asserts that these problems cannot be resolved because of "insuperable mathematical difficulties". As a matter of fact, most of the research effort of the past 15 years has been devoted to solving these problems so that the design engineer could use plastic design without having to cope with difficult stability problems. The very fact that a number of these problems have been satisfactorily solved in the past, indicates that the yet unsolved problems will yield answers so that the fields of application of plastic design may be increased in the future.

Thus the disillusionment of the author is not warranted. It took more than 200 years before the Theory of Elasticity reached its present sophisticated status, and even today there are still unexplored areas which need research. Why should the Plastic Theory then be rejected as a basis for design? Research is being conducted currently in many universities and new aspects of the theory are being cleared up constantly. The plastic method is now becoming an increasingly useful basis for design.

Before entering into detailed discussion on specific topics, the discussers would like to note the following:

(a) The proponents of plastic theory never have, and never can, suggest that it will supersede conventional elastic theory. A theory based on certain assumptions cannot be superseded by another theory which is based on different assumptions. Also, a thorough understanding of elastic behavior is necessary for understanding plastic behavior.

(b) The American investigations have always recognized that every design would have to be checked for such things as axial force, shear force, buckling of flanges, columns, and beams. But is this situation any different in elastic design? Certain "rules" were developed to make this task easy for the engineer who used plastic design. The main purpose of the "Commentary" is not to present the rules but to give the background of research and an outline of the solution (complicated in some cases) which lead to the simple rules.

Inelastic Lateral Buckling of Beams

The author states correctly that the influence of residual stress on the inelastic lateral buckling of beams can be quite considerable. He then continues to say that in elastic design these stresses are normally of no consequence. From the curves in Fig. 1 it can be seen that residual stresses do have an influence, but for certain practical reasons they are neglected in elastic design.

Fig. 1.

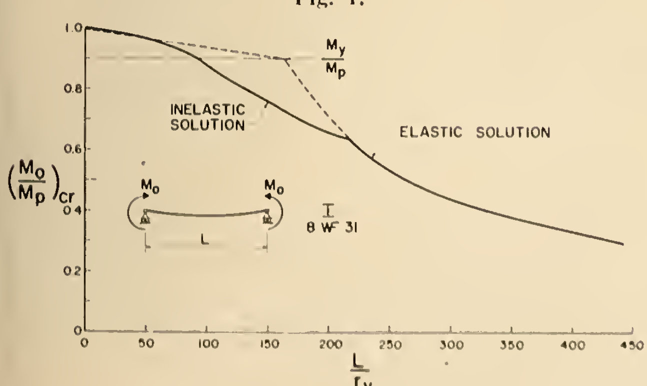
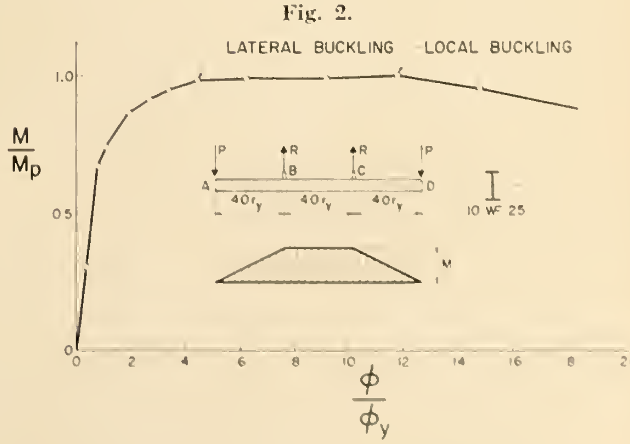


Fig. 2.



The curves in Fig. 1 show the relationship between the critical moment and the length of a simply supported beam subjected to uniform moment. Both quantities are shown non-dimensionalized as M_o/M_p and L/r_y, where M_p is the plastic moment and r_y is the weak axis radius of gyration. The section chosen for comparison is a mild steel 8WF31 section having the residual stress distribution of Fig. 7.12 of Ref. 5. The maximum compressive residual stress is $0.3\sigma_y$, and σ_y is 33 ksi.

The solid line in Fig. 1 consists of two branches: the elastic solution (for $L/r_y > 218$) and the inelastic solution (for $L/r_y < 218$). This inelastic solution[1] is based on a tangent modulus approach, and the reduction in stiffness due to premature yielding caused by residual stresses was included. It is seen that if the elastic curve is continued up to $M_o = M_y$, and if a straight line is drawn to $M_o = M_p$, then the results will be considerably on the unconservative side. When the curves based on the concept of elastic analysis are used, the lateral buckling curve is cut off at $M_o = M_y$ (dot-dash curve). In this case also, the procedure will result in a zone in which the results are unconservative. Thus the effects of residual stresses are not negligible even in elastic design.

The Spacing of Lateral Bracing

The author raises a number of questions about the theoretical treatment on the spacing of lateral bracing as summarized in the Commentary.[6] He concludes that the bracing spacing rules derived from the theory are:

(1) empirical
(2) unsafe
(3) cannot be verified by experiment

It is true that some empiricism entered the solution. However, it would be more accurate to say that the rules for the spacing of bracing are approximations. This fact, however, does not warrant the undue concern voiced by the author. All that is required of the lateral bracing spacing rule is this: if spacing is proportioned in accordance with it, the beam will perform its intended function without a reduction of rotation capacity due to inelastic instability. As will be shown subsequently, lateral bracing spaced according to the rules given in the Commentary (Eqs. 6.25) will fulfill this requirement.

The theoretical model on which the derivation of the rules is based assumes that the material is either elastic or strain-hardened. It is well known that as structural steel passes the upper yield point a zone of slip is formed in which the material passes immediately from the elastic limit to the point of strain-hardening. Subsequent straining triggers another slip band (or "yield line") until eventually the discontinuation point and the whole region reaches strain-hardening. A test of a tension bar with white washed mill scale shows this quite clearly.

At first, this appears to be in conflict with the concept that bending strains are proportional to the distance from the vertical axis. However, measurements confirm this concept quite well; and the reason they do is because the gages give an average of the elastic portion and the strain-hardened portions. Rather than being unrealistic and unsafe, the two particular assumptions which Prof. Hrennikoff criticizes are the most appropriate that can be made.

Considerable additional work has been in progress at the Fritz Engineering Laboratory in the past two years on the problem of bracing requirements in plastic design. A number of conclusions can be drawn from the results:

(1) The theoretical results presented in the Commentary are based on the tangent modulus concept (that is, no elastic unloading of already strain-hardened fibers is permitted). For beams subjected to uniform moment the critical length based on this concept is equal to 18 r_y. An upper bound analysis (based on the reduced modulus concept) has shown that the critical length is 40 r_y for rolled beams. The actual critical length should thus be somewhere between these two values.
(2) Carefully conducted experiments on rolled beams subjected to uniform movement have shown that the critical length (which is now limited to 35 r_y—see Eq. 6.25 in Ref. 5) could be extended to 40 r_y, or even 45 r_y, without impairing the inelastic rotation capacity of the beam. A typical test-curve is shown in Fig. 4 indicating the relationship between the maximum moment and the curvature at midspan. This curve shows that no unloading took place until a rotation of about 12 times the rotation at the theoretical onset of yielding was reached. This is adequate for plastic design.
(3) The basic mechanism of beam failure is well illustrated by Fig. 2. Lateral buckling commenced after the plastic moment M_p was reached. However, this buckling did not prevent the beam from continuing to rotate as a plastic hinge until failure finally occurred due to local buckling of the flanges. This type of failure mechanism was observed for all beams which were braced at a distance of 45 r_y or less. For beams braced at longer length, slow unloading commenced at the onset of lateral buckling. Thus for beams braced at $L \leqslant 45\ r_y$, a plastic hinge was developed. For these beams lateral-torsional buckling does not constitute failure, and the additional rotation is provided by post buckling strength.

The results of the above described new work not only show that the beam-bracing rules in Commentary are safe but that they might even be liberalised. It is also shown that the theory based on the concepts outlined in Ref. 6 is conservative when used to determine the critical bracing spacing.

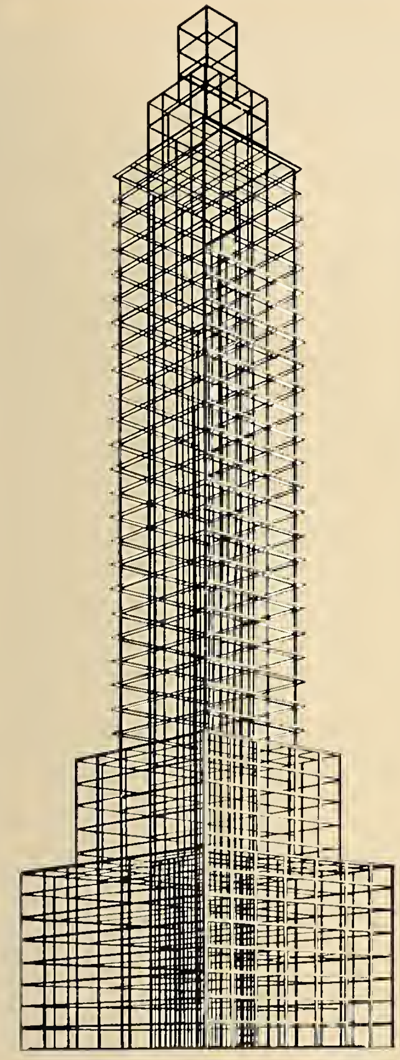
Incidentally, purlins in Fig. 6.23 of Ref. 5 are placed at the tension flange. Additional stiffeners or diagonal braces would be required at the corner to prevent lateral buckling.

The Behavior of Beam-Columns

The author criticizes the suggestion in the Commentary that beam-columns bent about their strong axes be braced against twisting in accordance with the beam-bracing rules mentioned earlier. This suggestion, however, is based on the results of 10 beam-column experiments on full sized as-rolled columns subjected to axial force and bending moment on one end. These columns were braced in accordance with Eq. 6.25 of the Commentary[6] (the actual bending moment distribution was used as the basis for the computation), and the columns performed satisfactorily. The columns carried their predicted load (Fig. 7.20 in Ref. 4), and their moment-versus-end rotation behavior was close to that which was predicted by theory. In addition to this experimental evidence, it also can be shown that the application of the strain-hardening theory (outlined in Ref. 6) yields the same results for beams as for beam-columns.

If the recommended procedures are followed, the rotation capacity required at the ends of columns will be adequate for the type of structure for which plastic design is now permitted. It was clearly recognized that rotation capacity would have to be studied further before plastic design could be applied to other types of structures. Theoretical solutions for predicting rotation capacity are now available,[2] and a comparison between

(Continued on page 66)



BUILD BETTER

WITH IMPROVED ECONOMICS OF

STRUCTURAL STEEL CSA G40·8

BUY CANADIAN

Guaranteed minimum yield strength of CSA G40.8 as supplied by Algoma is up to 33% higher than other structural grades, such as G40.4 (A7), permitting higher allowable design stress. In typical structures, use of CSA G40.8 can result in net weight savings up to 15% and more, with resulting economy in handling, transportation, and actual material cost.
CSA G40.8 is available from Algoma in plates, bars and structural shapes.

UP TO 33% HIGHER YIELD STRENGTH • SUPERIOR WELDABILITY • IMPROVED NOTCH TOUGHNESS

Further information, and copies of CSA G40.8 specification gladly supplied on request

THE ALGOMA STEEL CORPORATION, LIMITED

Sault Ste. Marie, Ontario

DISTRICT SALES OFFICES: MONTREAL • TORONTO • WINDSOR • HAMILTON • WINNIPEG

theory and experiment for the above mentioned 10 beam-column tests is excellent.

It is recognized that interaction curves are given only for two types of loading in the Commentary (equal end moments causing single curvature deformation and for columns subjected to end moment at one end only). Further solutions for other pertinent loading cases have been available for some time and will soon be appearing in print.

Effect of Creep on Experimental Results

Both the Commentary and the articles leading up to it have recognized that steel "flows" in the plastic range and that the measured load is a function of strain rate. However, this is definitely not a factor in the tests. All of those conducted at the Fritz Laboratory employed one of two techniques in the plastic range: "constant load" or "constant displacement". In the first, after a small increment of load was applied it was held constant until plastic flow ceased. Only then were readings taken. Similarly in the second method: no readings were taken until the load had stabilized. By using this time-consuming technique in the laboratory it was assured that the results represented a "static" condition. A real structure would thus be stronger than its laboratory counterpart.

Connections

The author expressed dissatisfaction with the assumption of flange force made in the Commentary for the purpose of determining the adequacy of the connection web and diagonal stiffener. By assuming a flange force $T = M_p/d$ (which is some 15-20% greater than any the flange will actually have to carry) the required web thickness to carry this larger force will be conservatively estimated. In other words, the web thickness or diagonal stiffener and weld size computed will be slightly greater than needed to carry the actual flange force. It is true that the web will actually carry some normal stresses and the flange will carry some shear stresses. The exact distribution is not essential since the lower bound theorem can be satisfied by providing sufficient material to carry the applied moment and forces in some manner. The ductility of the steel will permit some redistribution of stresses to allow the connection to do its job. The results of severe corner connection tests on rolled shapes from 8 in. to 36 in. depths have shown that such connections develop the plastic hinge moments of the beams and that the welds are adequate. (References 8.4, 8.5, and 8.6 of the Commentary.)

Conclusions

Many further arguments could be brought up in defense of the plastic theory, but it is considered that these are adequately covered in the Commentary.

The author fears the complexity of plastic design. But engineers who are now using it are finding that just the opposite is the case. In many parts of the United States its application is so frequent as to be commonplace. After careful and independent study, the U.S. Army Engineers has now authorized its use in both military and civil structures. Thus all major code-writing groups in the U.S. have recognized its merit.

Make no mistake about it, complexities are there. But it is the job of the researcher to solve the complex problems and present them in convenient form for the engineer to use. To cite a contemporary example, Cdr. Shepard only needed to use the convenient manipulators to control the first space craft. Someone else solved the complex problems. Had he looked for the complexities, he would never have left the ground.

It is also the task of research workers and educators alike to recognize the problems that exist, because only in that way may progress be made. Some of Prof. Hrennikoff's remarks point to questions whose solution will clear the way for further practical applications; here he had made a contribution to the profession. However, the discussers re-assert that his criticism of present practice of plastic design as set forth in the Commentary is not justified. Plastic design is at least as well founded as "elastic" allowable stress design.

References

1. Galambos, T. V. **"Inelastic Lateral Buckling of Beams"**. Fritz Laboratory Report No. 205A.28, October 1960.
2. Ojalvo, M. **"Restrained Columns"**, Proceedings of the ASCE, 86 (EM5) p. 1 (Oct. 1960).

Discussion by J. F. Baker

Prof. Hrennikoff has examined critically some aspects of structural design. From many points of view, his paper might be called "Weaknesses of the Theory of Elastic Design", since some of the detailed criticisms apply to any steel structure, independently of the way it was designed.

Prof. Hrennikoff is particularly concerned with the effect of instability phenomena on plastic design, and he is right to be so concerned; but he ignores the fact that instability whether of the structure as a whole or of individual members, is also one of the chief difficulties of elastic design.

Let us admit at once that the plastic theorems, which are so powerful in analysis and design, can be proved rigorously only for structures which remain stable. Upon making a plastic design, the designer must check carefully that his fundamental assumptions are not violated; for example, deflexions must remain small, plastic hinges must develop without local instability occurring, complete members must remain stable, and overall frame instability must not occur. These overriding design conditions apply to any structure, whether designed elastically or plastically.

If there is any danger of a design violating the conditions, modifications must be made to the structure. In the worst case, a full analysis, elastic as well as plastic, must be made for the whole structure under all possible loading conditions, and allowing for the real state of the structure. The "real" condition of the structure differs from the "ideal" condition of the model structure assumed in analysis and design. Real conditions may include: an initial residual stress system, whether induced by welding, by imperfect fit-up, by settlement of supports, or whatever other cause; connections which are flexible to a greater or lesser degree; accidental imperfections in the members of the material, and, in short, all the ills that a structure is heir to.

All these remarks apply equally to elastic as well as to plastic design. It is the particular contribution of plastic theory that it has proved, for a wide range of structures, that many of the real conditions have negligible or zero effect on the carrying capacity of the structure. The elastic designer would in any case ignore most of the real conditions; his plastic colleague has justified his temerity.

It must be remembered that engineering design, however, concrete the result, is essentially an abstract process. It is an exercise in mathematics applied to a model of the real structure. Accurate theory will predict accurately the behaviour of the model; whether or no the actual structure behaves like the model depends on the care with which the model is constructed. Now the models constructed by both elastic and plastic designers are essentially the same. If the plastic designer is worried by deflexions, or by instability, and decides to allow for these in the analysis, then so also will be the elastic designer. On the other hand, both may ignore a certain set of imperfections as being virtually certain not to affect the design.

The essential difference between elastic and plastic methods is that the latter will predict accurately an observable quantity for the structural model, i.e. the load factor against collapse. Elastic analysis, however, predicts no real quantity; it predicts stresses, and, as all tests on real structures have shown it predicts these badly. Further, plastic

(Continued on page 68)

theory has demonstrated how the structural model should be constructed; for example, instead of guessing that the settlement of a support to a continuous beam will have negligible effect on the collapse load, it proves this. This illustrates the simplicity of the plastic method; the elastic designer would reach an opposite conclusion, and much design time would be wasted in allowing for settlement of supports. Further yet, since plastic theory calculates a real quantity in the analysis of a structure, it is possible, virtually for the first time, to construct a rational design process.

Thus the designer can, by a direct plastic method, or by cut-and-try elastic methods, design the model of a given structure. It remains to decide whether this model will serve as the basis for the actual structure. This question is completely independent of the design method used, and many of Prof. Hrennikoff's criticisms are really aspects of this question, and not criticism, of the plastic design method alone.

We do not claim that all the problems of plastic theory are solved. The state of the art is not yet advanced enough to predict accurately the behaviour of the model under all conditions, nor to answer fully the question as to whether the model is a permissible representation of the actual structure. The theory has been advancing step by step, and has been applied to more and more complex structures, from continuous beams to heavy plate girder grillages, from portal frames to multi-storey office blocks. At each stage in the advance gaps in the theory have been disclosed, and attempts made to close these gaps. And, at each stage, experimental work has checked the theoretical predictions.

At the end of this paper Prof. Hrennikoff states that the plastic theory claims to give (a) simplicity of design, (b) a more realistic factor of safety, and (c) better economy. He denies these claims for other than simple structures not subject to instability.

When buckling may occur, plastic theory becomes less simple. But it does not become complex compared with an elastic theory aiming for the same realistic factor of safety; it becomes complex only compared with simple plastic theory. The problem must be stated in the right terms. If the designer wishes to design a structure realistically, and economically, then the design method may become complex; plastic theory is essentially realistic, and hence almost inevitably economical. While elastic theory may be rational as applied to the idealised model of the structure, elastic design as applied to the real structure becomes largely a collection of empirical formulae; the more empirical the formulae, the less realistic will be the design, and the worse the economy.

Plastic theory attempts, above all, to stand fast by realism; as more complex structures are designed, so the theory becomes less simple. But, at the first sign of heavy weather, elastic theory throws realism overboard, in an attempt to conjure the zephyr calm of simplicity; and simplicity is the treacherous song the Sirens sing.

Discussion by Dr. Jack R. Benjamin

The weaknesses of plastic procedure must be viewed both in their relation to science and the comparable weaknesses of conventional elastic theory. Most of the questions raised have equally severe counterparts in conventional elastic theory. Our extensive experience and native conservatism with elastic concepts have kept the proportion of failures small, although the elastic theory of columns has yet to catch up with practice. Yet, we have been using empirical relationships for many years with minimum difficulties. A more critical condition exists with respect to lateral buckling. Almost every phase of elastic design contains unanswered questions.

Unfortunately, research on plastic theory and design has been almost entirely concentrated on practical expedients for design. The published information is more concerned with building code content than pure science. The objective has been to arrive at reasonably conservative empirical relations with a minimum of costly laboratory experimentation. The entire attitude has been to form a new body of code information that will allow plastic design to be used in practice in as short a period of time as possible and at minimum cost.

Prof. Hrennikoff is correct in his comments on buckling involving plastic deformations. Many years of investigation will be necessary with thousands of tests before all major questions are answered satisfactorily. The range of column sections used experimentally at Lehigh is very limited. Major questions are certain to exist that can only be studied after real structures are built and exposed to severe use conditions.

The entire question of lateral and torsional buckling of beams must receive further study including a great deal of costly experimental work. How much support is lateral support? This basic question is largely unanswered and conveniently ignored in current design practice, elastic or plastic.

The theory for the three typical A.I.S.C. column cases is most incomplete and very poorly presented for code inclusion. Although the simple tables and graphs fit almost all columns the designer will meet, a few special cases always arise. The procedures available in the literature allow reasonable elastic design for almost all conditions. The same is far from true with plastic design. In fact, the empirical code relationships do not even fit an elementary theory designed to allow engineers to reason about columns and their behavior. These questions were not considered expedient.

Regardless of theory and code provisions, the engineers, responsibility is linked to performance. A basic change in design procedures must be reviewed in the light of real service and probable overloads, and the resulting performance of the structure. The advent of plastic theory and design has been a major step forward. However, every change does involve an unknown risk. In this light, Prof. Hrennikoff's paper is most important and deserves careful study.

The writer agrees with Prof. Hrennikoff in the view that adequate theory for both analysis and design is vital. The major effort has been in the preparation of rules for design, many of which are empirical in nature. In view of the legal and moral responsibilities of the structural engineer, the development of complete analysis tools is imperative.

The entire matter of real vs. assumed loadings, alternate loadings, and combinations of dead, service, and lateral loads must be reviewed carefully. In many cases plastic design procedures will produce considerably lighter designs than current elastic specifications. Conservative practice with elastic procedures differs from similar conservatism with plastic procedures.

The advent of plastic theory and design has been a major step forward. However, every change does involve an unknown risk. In this light, Prof. Hrennikoff's paper is most important and deserves careful study.

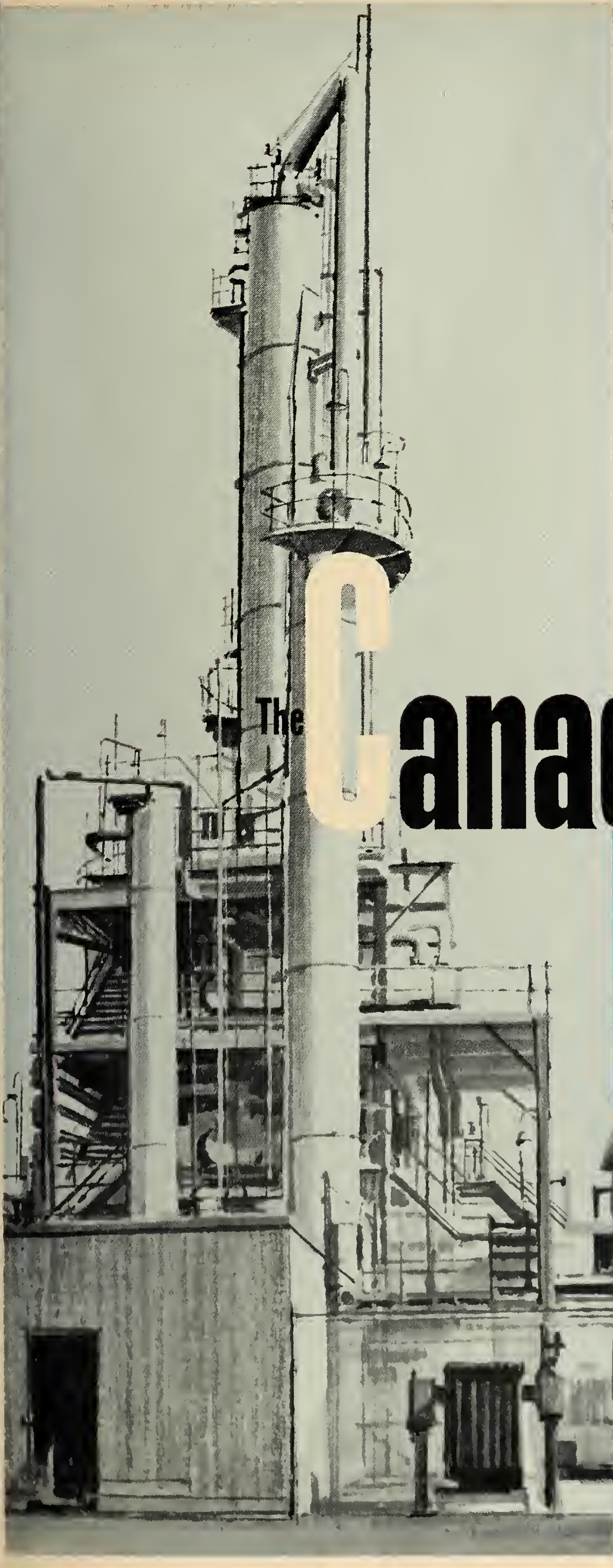
Discussion by W. J. Sutcliffe

I agree with the reasons given why the true collapse load of a structure is not readily calculable. Plastic instability of beams, inadequate column theory and frame instability make collapse loads given by the simple plastic theory incorrect. It follows that the mechanism condition defined as failure according to plastic theory is difficult to determine and may be quite unlike the condition of the structure under working loads. If parts are designed to suit the mechanism condition sizes will be different from those obtained using an elastic method. Do the proportions produced by the plastic method lead to economy of material? It would be strange if design at a condition far removed from the condition under working load produced an ideal structure for withstanding that working load.

I deny however that even where the simple plastic method is applicable it gives any advantage in economy. The standard case of the fixed end beam, for instance, is better considered not as a case where plastic theory leads to a lighter design but as a poor design from an elastic viewpoint which should be improved by decreasing the rigidity of the supports.

The plastic design for the extension to the Cambridge Engineering Laboratory is said by its designers to save 19% of steel. This is a very misleading statement. Exact elastic analysis gives maximum beam stresses ranging from 9.2 tons/sq.in. to 11.9 tons/sq.in. While the beams are thus more or less satisfactory, the stanchions have been overdesigned as a low working stress has been used here. If the stanchions were reduced, then the end moments on the

(Continued on page 70)



beams would be reduced and further weight could be saved on the beams. Thus a correct elastic design would give some economy over the present plastic one. The alleged saving of 19% is by comparison with an elastic design where the beams are considered to be simply supported!

The presence of residual stresses is often given as one of the main reasons for abandoning elastic methods. Professor Hrennikoff has drawn attention to the errors which may arise in neglecting such stresses where plastic instability occurs. In elastic design they can be neglected as superposition allows consideration of the applied stresses only as giving rise to linear behaviour.

A curious feature of the plastic design method is that it is only applicable to imperfect structures such as those containing untapered beams. An ideal structure exactly proportioned to the applied loading would yield in all parts at the same load and all parts would fail soon afterwards. Elastic analysis of an imperfect structure shows how the ideal can be approached. Thus there is the rather peculiar situation that plastic theory, if it has any advantage, (which I deny), then this advantage only arises for an imperfect design. As a design improves towards the ideal, plastic and elastic designs become identical.

Luckily for the plastic theorists the plastic/elastic controversy can hardly be decided by test. For plastic designs have generally acceptable elastic stresses under working conditions. Any differences in resulting structures are blanketed by the enormous (and necessary) reserves of strength. If a plastic design leads to an economy in material this is hailed as showing a superior strength/weight ratio whereas it could often be more realistically described as being a design to a lower safety factor in that part.

Air raid shelters may be designed to absorb energy by folding up to some extent but buildings should be designed to stand up not just not fall down.

Discussion by D. T. Wright

In raising questions about various aspects of the application of the theory of plastic limit design to street structures, Prof. Hrennikoff has provided an opportunity for a certain re-examination of our present status in respect of both elastic and plastic methods of design.

It is to be hoped that discussions to this paper will provide two kinds of comment: first, detailed point-by-point replies to the specific questions raised by Prof. Hrennikoff, and secondly, and perhaps even more importantly, general comments on the significance of the supposed "weaknesses" of both the plastic and elastic design theories.

In view of the nature of the development of work on the plastic theory of design in England and North America, it would appear to be most appropriate to have the detailed reply to Prof. Hrennikoff's comments undertaken by the very people whose work is questioned, namely, Prof. J. F. Baker of Cambridge University, who has been responsible for most of the development of the plastic method of design, and Prof. L. S. Beedle of Lehigh University, who has been responsible for much of the research work done in the United States and, as well has provided most of the guidance in the preparation of the "Commentary on Plastic Design" of the American Society of Civil Engineers.

It certainly seems most important for the concern expressed by Prof. Hrennikoff to be put in proper perspective. It is not the intention of this discussion to present a point-by-point reply to the questions, since such replies can undoubtedly best be made by the people noted above. Instead, comments will be offered on some only of Prof. Hrennikoff's ideas in terms of both their immediate context, and the more general problem.

As Prof. Hrennikoff indicates in the final section of his paper, the advantages of plastic design in providing a) simplicity, b) rationality, and c) economy, are to be conceded — in the absence of buckling. Many of Prof. Hrennikoff's specific comments deal with problems in the analysis of the instability of partially plastic members. It has been the objective of the design methods established under the auspices of the Committee on Plasticity of the American Society of Civil Engineers, as developed in the "Commentary", to provide designs in which failure modes would be governed by simple plastic behaviour rather than instability, through the provision of restraints and inhibiting influences against instability. The validity of this approach has been demonstrated repeatedly through experiments on full scale structures in which load-deformation graphs show still-increasing load carrying capacity far beyond the attainment of the plastic load capacity and well into the region in which local and even general instability has developed.[1]

The very essence of the scientific method is the confirmation or rejection of postulates and theories on the basis of experimental evidence. The experimental verification of plastic theories, thoroughly catalogued in the "Commentary" clearly demonstrates the scientific base of the plastic design method. On the other hand, the inadequacies and weaknesses of elastic theories for the behaviour of structures, though perhaps not as appreciated as might be appropriate, have been thoroughly demonstrated.[2] That structures designed elastically survive at all seems to be entirely due to plastic reserves of strength.

Turning in a more general way to the problem of the design of structural frameworks, it is evident that much of our success in designing structures that actually survive is due rather more to the actual character of loadings than to the adequacies or inadequacies of elastic or plastic design methods. Most structures would be very embarrassed if all the loads their designers presumably anticipated were, in fact, to be applied simultaneously. Of course, the extreme improbability of occurrences of most critical loadings on frames of any size or complexity, is such that it seems less likely to have such occurrences than it is even to experience material strengths, by chance, at levels as low as working stress magnitudes.

One of the most surprising points raised by Prof. Hrennikoff is the question of analysis versus design. Prof. Hrennikoff suggests that "plastic theory deals only with design and not analysis". Perhaps some definition of "analysis" is required, but in structural mechanics it is usually associated with the analytical determination of the characteristics of a given structural system. The theories and methods of analysis are of course established and judged on a scientific basis — by their ability to predict physical behaviour. It has been very well and often demonstrated that the plastic theory is a most effective tool of analysis in respect of its ability to predict load capacity. There has been difficulty in developing associated analyses to determine deformations, but some important progress in this connection is found in a recent paper by Heyman.[3] Elastic theory purports to provide a basis for structural analysis, but its shortcomings have been thoroughly exposed. Although most structures designed by elastic theory do survive, elastic analysis is rejected by scientific examination when its predictions are confronted with experimental evidence. It is particularly interesting to note that the type of analysis provided by plastic theory, i.e., the ability to predict maximum load carrying capacity, ordinarily without a direct indication of the associated deformation, is precisely the same as the type of analysis provided by the theory of elastic stability in which critical loads are determined without indications of the associated strains or deformations. There is thus a very close analogy between the modern plastic theory and the earliest beginnings of the science of structural mechanics as exemplified by Euler's analysis for the load-carrying capacity of a buckled strut.

It is very distressing to realize that traditional "elastic" design, as observed in codes and specifications, is a hodgepodge in which three main and incompatible streams can be traced. The first is the classical elastic theory of structures which, as previously noted, is conspicuously unsuccessful in fulfilling its avowed objectives of predicting stresses or strains. The second, is the application of plastic limit analyses, never acknowledged, and not even appreciated in part by most designers through which most connections particularly riveted joints, are designed and "analysed". Were elastic theory used to "design" connections we would be most unhappy indeed! The third stream, of course, relates to stability problems which, as Prof. Hrennikoff has clearly shown, are the most contentious area of the theory of structural mechanics, and for which it is never possible to know more than the critical load. Although designs is based upon a "factor of safety" against

(Continued on page 101)

Canadian Developments

Canada Participates in the Upper Mantle Project

Canada will be an active participant in the Upper Mantle Project. The activities of the project are the counterpart of the International Geophysical Year in that scientists all over the world will co-operate in a study of the earth's interior. The Project, proposed at the triennial meeting of the International Union of Geodesy and Geophysics in 1960, has been ratified by several other countries including the United States and the Soviet Union. Preliminary work on the scope of the Project in Canada has been done by the Scientific Committee of the Upper Mantle.

The earth consists of three layers; crust, mantle and core. Man lives on the resources of the crust. The mantle below controls conditions within the crust. Mountains are thrust up by forces within the mantle and form major fault zones which act as channels for magmas or molten rock to carry minerals to the crust where they may form ore bodies.

For this reason Canada can profit greatly from the study. The Project will yield valuable information on the locale and formation of minerals especially metals such as nickel, chromium and platinum. Deep drilling in hard rock will be done down to 10,000 ft., a depth never attempted in Canada before. This will provide vital information on hard rock drilling. Most of the projects to be done during this three-year period of study represent either a speed-up of work already being carried out by the Department of Mines and Technical Surveys or work planned. The direct approach of geology and the indirect approach of geophysics are the two methods of study to be implemented.

Seven per cent of the earth's crust is exposed in Canada. Except for Russia, a greater variety of the earth's geological units are exposed here than in other nations. Canada is one of the few countries having a large expanse of Precambrian rocks. These should provide scientists with clues to the nature of the mantle during the earth's early history.

A four-point program has been planned by the Geological Survey of Canada to provide information of the composition of the mantle and its influence on the crust.

1) On a horizontal plane geologists will make detailed studies of certain igneous intrusions of mantle material. These will be examined chemically, petrologically, mineralogically and isotopically. They will be the "windows" by which the interior of the earth can be studied.

2) On the vertical plane samples of material not exposed at the surface will be deep drilled. The chemical changes of these samples as they are affected by depth will be noted so that this data can be extrapolated to depths below the reach of today's drilling equipment. Two 10,000 foot holes will be drilled; one in the Muskox Instrusion in the Coppermine area in the Northwest Territories and the other in Mount Albert in Gaspé, Quebec. The Muskox Intrusion is considered one of the world's best exposed bodies of layered-type ultra-basic intrusions. Detailed geological and airborne magnetometer studies of it have already been made by the Geological Survey. The intrusion at Mount Albert is in the thinner part of the crust near the continental margin. As hard-rock drilling has reached only to the 7,000 foot level in Canada, special equipment for the Project will be required. Each of the 10,000 foot holes will take a year and a half to drill.

3) The Geological Survey of Canada in co-operation with the Geological Association of Canada and the Alberta Society of Petroleum Geology is compiling a tectonic map of Canada. This map will bring new light on the major geological structures in Canada which reflect crustal conditions and provide valuable information on conditions governing metal deposits. The $18 million Federal Provincial program of aeromagnetic surveying now underway will provide a large amount of data to assist survey geologists in understanding the regional geological picture.

4) Palaeomagnetism, the study of fossil magnetism, will be used by survey geologists to study both the mantle and crustal structure. Many rocks retain the magnetism present when they became consolidated. Geologists and geophysicists by these studies can learn more about polar wandering and continental drift. Both phenomena are directly related to past and present conditions in the Upper Mantle. The diabase dike system which spreads across the Canadian Shield will be the focus of Canadian studies. One geologist has called this unusual feature "a geological afterthought by Pluto, the god of the underworld. These dikes are so widespread and so uniform in composition that they seem to have been spewed up simultaneously from the depths of the crust".

Depths beyond the reach of drilling will be studies by scientists from the Dominion Observatory who will use seismological, gravity, and the study of earth currents and heat flow in their research.

Seismological data will be obtained from two sources: First, network of seismic stations will be established at 500 mile intervals throughout the country. There earthquake waves will be measured and studied to learn more about the forces active within the mantle and physical characteristics peculiar to the earth's interior. Second, explosion seismology will be used to determine the depth of the mantle beneath the earth's crust. This method offers the advantage of controlled conditions for investigation.

Some 30 stations equipped with standard equipment will make up the seismic network. This program was already under way when Canada decided to participate in the Upper Mantle Project. To meet the requirements of the Project the Dominion Observatory will speed the completion of the installation of the complete network. Instead of being completed in five or six years as originally planned, it will be completed in three. Stations now open are at Alert on northern Ellesmere Island, Mould Bay and Resolute in the N.W.T.; Victoria and Penticton, B.C.; Banff, Alta.; Ottawa, Ont.; Montreal, Seven Falls and Shawinigan, Que.; and Halifax, N.S. A station at Port Hardy, B.C. is now under construction. Planned for completion at a future date are stations at: Whitehorse in the Yukon, Inuvik, Coppermine, Hall Lake, Baker Lake and Frobisher, N.W.T.; Port Nelson, B.C.; Edmonton, Alta.; Fort St. James and Churchill, Man.; Kenora, London and Scarborough, Ont.; Port Harrison, Fort Chimo and Schefferville, Que. and at St. John's, Nfld.

While studying earthquakes, Observatory seismologists will continue their work in mechanism, the manner in which the earth moves during an earthquake. Mechanism is a field in which the Observatory has been a world leader for some time. It has published more mechanism studies of large earthquakes than any other institution.

(Continued on page 75)

International News

Calder Hall Nuclear Power Station Is Model for New Units in England

The Calder Hall nuclear power station in Cumberland, England, is now supplying about 1,000 million kilowatt hours of electricity to the British electricity grid system each year. The total provided since 1956, when the station went into operation, amounts to almost 3,500 kwh.

Calder Hall was the first station to show what could be done to derive power safely and successfully, and on a large scale, from a new primary source of energy. It is one of two dual-purpose stations—designed to provide plutonium and nuclear power—built by the United Kingdom Atomic Energy Authority (UKAEA); the other similar station is at Chapelcross, near Annan, in Dumfriesshire, where the four reactors have been in full operation since the beginning of 1960.

Each Calder Hall reactor is charged with 130 tons of natural uranium in a core of 1,100 tons of graphite and has a gross electrical output of about 42 megawatts, giving a total for the plant of 168 Mw. Modification of the steam turbines by means of reblading is to bring the gross figure for electrical output per reactor to 54 Mw., an increase of about 28% on the original expectation. They are operated to provide for the base load needs of the electricity authorities, but have to be shut down for fuel changes. This consists of removing and replacing approximately 10,000 radioactive fuel elements using remote handling equipment working through gas seals.

A series of engineering modifications have reduced the shut-down period for a complete fuel change from about 80 days to three weeks. Another notable improvement in efficiency is the progressive raising of the heat output, which is now some 20% about the design figure. It is noteworthy that No. 4 reactor completed 12 months continuous operation on Jan. 31, 1961, during which period it was generating electricity at full load for 95.6% of the time. Most of the time not on full load was devoted to experimental work and scheduled maintenance.

The stage has now been reached when the reactors are capable of generating more steam than can be used by the installed turbine capacity, and the modifications being made to the turbo-alternators will utilize the excess steam. In addition, the latter is to be used in the chemical plants at Calder and for space heating.

Calder Operations School

The UKAEA has set up an Operations School at Calder for the training of reactor operators for nuclear power stations. Courses, the first of which started in January 1957, normally last six weeks, and students receive both theoretical and practical instruction in the operation of reactors of the Calder Hall type, working both with a simulator and with operational staff on the Calder Hall plant itself. Recently the training of staff for nuclear power stations being constructed in Italy and Japan by British Consortia has been an important part of the school's activities. About 530 students (one-third coming from overseas countries) have attended the school since it started.

The eight stations now under construction by the electricity authorities as part of Britain's nuclear energy program are based on the Calder Hall prototype. By 1966 these stations will be providing 3,000 Mw. of generating capacity; their electrical output ranges from about 275 Mw. in the case of the Berkeley station to 580 Mw. for Sizewell. Bradwell and Berkeley, the first two of these stations, will be in full operation by the spring of 1962, and loading of the reactors is now proceeding.

The greater electrical output of these nuclear power stations has been obtained by an increase in the size of the reactors and in the uranium fuel content, by raising the heat ratings of the fuel and also by an increase in the efficiency of the conversion of heat to electricity. Thus the Hinkley Point nuclear power station uses two reactors each developing 965 Mw. of heat and producing 250 Mw. of electricity.

A new generation of reactors is represented by the advanced gas-cooled reactor (AGR). A prototype with an electricity output of 30 Mw. has been built at Windscale, in Cumberland, and fuel loading is due to start shortly. The AGR will operate at much higher steam temperatures and thus have a higher thermal efficiency, and enable further reductions to be made in the capital costs of the reactor installation. Uranium oxide will be used as fuel instead of natural uranium and the canning material for the fuel will be either of stainless steel or possibly beryllium metal, instead of the cans of magnesium alloys used in the Calder Hall type.

Mobile Laboratory

A mobile laboratory which has aroused international interest has been designed by the Oak Ridge Institute of Nuclear Physics. This coach was developed to move radio-active isotopes to training and university centres in all parts of the world.

Its main value is as a training unit for teachers and student groups in the methods and equipment essential to the study of isotopes and related subjects.

The vehicle, with a 208-inch wheelbase, has an inside length of 28 feet. The inside width and height are about 90 inches. It is fully insulated with fibre-glass and aluminum foil for complete comfort under all climatic and atmospheric conditions.

There are double windows throughout, and a three-ton air conditioner housed beneath the floor is ducted to the ceiling for maximum distribution of the conditioned air. Other features include metal cabinets and fume hoods, fluorescent lighting, stainless steel water and waste tanks, a 160-foot power cable, a radiation vault, seating facilities for students, and hydraulic levelling jacks.

A Laboratory Manual prepared by ORINS lists the strict rules of housekeeping which must be followed by all who use the mobile laboratory. Included are a series of restrictions, and procedures to be followed in the event of an accident.

The mobile laboratory will be expensive to transport to areas beyond the reach of the vehicle's own power. Structural quality and the somewhat brittle nature of its contents will contribute to high freight and insurance rates.

(Continued from page 72)

Two field parties of Observatory seismologists will continue to use explosion seismology to supplement data received from the seismic network. These teams are situated in the Vancouver Island area and on the polar continental shelf in the Arctic. Working with a dozen to two dozen instruments their observations yield valuable and interesting data on the structure and thickness of the earth's crust and the depth at which the upper mantle begins. In eastern Canada the mining industries are co-operating with the Observatory to obtain seismic data from routine mine blasts.

At most of the seismic stations holes will be drilled and temperature measuring devices installed to measure heat flow from within the earth. Heat flow measurements from holes drilled in ultrabasic and granite rocks and in meteor craters will also be taken. They will give information on the heat flow from the mantle through the crust. The scientists will then be able to tell whether the interior of the earth is heating or cooling.

A two point program in gravity has been planned by the Observatory.

1) Regional studies of gravity changes which show variations in the depth through the crust to the mantle.

2) The gravity survey of Canada, underway for some years, will be completed so that the results can be used by geodetic, military and commercial interests. This type of survey yields information about local geological formations of potential interest. Gravity will be used to measure earth tides. The resulting information will inform the scientists about the elastic constancy of the earth under the influence of gravitational pull and the physical nature of the material being displaced by the tides.

Canadian work in geomagnetism will centre on the use of magnetic studies to estimate the electrical conductivity of the earth. Geophysicists working at the Station at Meanook, Alta., and at the Defence Research Board station at Suffield, Alta., plan to extend their frequency range.

The study of meteor craters is another of Canada's contributions to the Upper Mantle Project. These craters will, the scientists believe, yield much information on the mantle. Meteor craters are believed to be similar to those on the moon. Dominion Observatory Scientists have found a number of them in Canada.

A circular feature in Hudson Bay, believed to be a meteor crater, will be studied. Located near James Bay it is almost 300 miles across. If it proves to be of meteoric origin scientists will drill near the edge to study the floor of the crater as well as samples of rock fractured by the impact. Should it be a meteor crater scientists estimate that the crust would have been shattered to a depth of 100 miles. A 200 mile feature in the Gulf of the St. Lawrence near Prince Edward Island may also be studied. EIC

Month to Month

University Registration

A slight decrease has been noted in this year's university engineering enrolment as tabulated by the Institute from information obtained directly from registrars.

Several highlights of this year's situation, as revealed by the E.I.C. survey, are:

Total enrolment in Canadian engineering courses now stands at 14,890, a decrease of 50 from last year.

The estimated number of 1962 graduates, making no allowance for wastage during the year, is 2,590. This is a decrease of 61 from the previous year.

Engineering freshmen numbered 4,718 in the autumn of 1961, an increase of 257 from the autumn of 1960.

Civil, electrical and mechanical engineering remain the most popular courses. Following is a list of the 1962 graduates, with the previous year's estimates in brackets: Civil 771 (779); Electrical 643 (644); Mechanical 494 (508).

Readers will be able to make further detailed observations by study of the tables. If any questions should arise, E.I.C. Headquarters will gladly try to answer them.

E.I.C. ELECTIONS AND TRANSFERS

A number of applications were presented for consideration and on the recommendation of the Admission Committee, the following elections and transfers were effected at a meeting of council on October 28, 1961.

Member:
S. F. Clark, Ottawa; A. C. Cooke, Montreal; K. Deenstra, Niagara Falls; M. W. Delorme, Montreal; D. W. Dibben, Belleville; J. Dyson-Gregory, Toronto; L. K. Jacobsen, Port Cartier; H. W. S. Marshall, Toronto; C. McGinnis, Vancouver; A. D. Miller, Ottawa; D. G. Poitevin, Sudbury; A. W. Pratt, New Westminster; J. P. Sinclair, Vancouver; R. Steketee, Windsor, Ont.; A. E. Wright, Vancouver.

Associate:
C. R. Ahooja, Montreal; J. Khanna, Vancouver; K. L. Lee, California; F. W. Sagan, Windsor, Ont.; A. A. S. Saleh, Montreal; A. W. Wenger, Montreal.

STUDENTS ADMITTED

McGill University:
B. H. Aghadjanian, S. Albert, E. A. Anyahuru, A. C. Archibald, E. I. S. Aronson, B. S. Atlas, R. E. Bailey, R. J. Barrie, J. S. Binok, D. J. Bland, L. A. B. Bowen, B. D. Booth, C. B. Bowen, A. R. Brooks, G. H. Brown, H. C. Brown, R. Brown, J. K. N. Burke, D. A. Calder, R. A. A. Callahan, J. J. Castonguay, M. Chai-Onn, Chan-Hor-Kay, G. Chevassus, P. B. Cooper, R. G. Cooper, T. L. E. Cunard, J. R. Darling, J. L. B. de Bast, A. I. Dunsky, P. N. Elliott, M. D. Everell, K. D. Farmer, M. A. Farrugia, L. Fattal, G. W. Fenton, A. R. Flanz, F. S. Gasoi, M. J. Gilbert, D. A. Gillman, G. S. Goppold, G. B. Hall, B. A. Harrison, A. Hering, M. L. Hess, H. W. Hinds, R. P. Houston, W. G. Hutchison, C. W. Jones, K. S. Kalman, J. Kaufman, A. Kavalersky, P. S. Kentebe, L. R. Kerr, A. A. Klein, C. H. Kong, G. P. Korber, R. A. Krajewski, C. Lafond, C. K. Lai, P. C. K. Lam, J. A. G. Lamontagne, R. D. F. Lawson, M. Lazarus, C. Lee, J. B. A. Lenger, C. V. Leroux, P. G. Leroux, I. S. Levitan, S. Z. Lewin, J. G. Leworthy, P. A. Lowe, Ma Che Keung, D. H. MacKay, J. M. Mahfood, R. Makinen, G. E. Malone, B. R. Marshall, D. B. Martin, S. B. Matthews, J. H. Mattinson, A. S. Maxwell, H. Mayers, M. G. McGarry, L. B. McLearon, R. D. Melville, M. Merilo, R. B. Michaliszyn, O. G. Mickevics, R. N. Miller, K. B. Mitchell, W. G. Moeller, D. T. Moodie, D. H. Moon B. G. J. Murphy, L. A. Murray, S. Nador, G. R. D. Nelson, R. E. B. Nicolle, S. Niedzviecki, M. N. O'Gallagher, T. I. Okeke, M. Ouimet, J. Pascual, R. Y. Patenaude, R. C. Payette, T. Pikksalu, L. H. Polkki, K. Porter, N. O. Powell, J. W. Ratcliffe, J. A. Read, K. A. Roberts, W. F. Rodger, G. S. Sabourin, J. Schiff, R. M. Schwarz, J. M. Scott, S. C. Scott, K. J. Seto, G. T. Shepherd, B. M. Shiller, M. Shostak, I. P. Shunriwsky, R. M. Skanes, L. A. Smith, R. H. Smith, L. A. Snider, J. H. C. Soule, P. E. Statham, S. A. Stephens, C. H. R. Stevenson, H. Stotland, G. H. Sumner, D. G. Symonds, H. Tamm, T. I. Tenn, E. Yuet-Ngan To, I. V. Tolensky, J. Toth, P. Tremblay, C. D. Trent, Y. H. Trottier, R. Y. S. Tse, Li Wing Tuck, Kevin U, M. C. Valentine, J. Van Dostrom, B. L. Walker, W. J. Warner, R., Weiser, D. S. Weiss, P. Weisshuhn, A. M. Wiebe, E. G. S. Williams, L. Williams, G. F. Windsor, S. R. Winter, J. C. Y. Wong, M. C. Woo, S. A. Yaphe, J. Zacharatos.

University of Western Ontario:
G. S. Aitken, J. Aitken, D. Alexander, J. C. Alexander, D. R. Allison, R. L. App, P. Barnett, P. J. Bird, B. P. Brady, J. Brister, S. R. Bycraft, S. Byma, W. D. Chambers. J. R. Conway, F. E. Crawford, F. J. Daigle, A. C. Davanzo, R. B. Duncan, A. W. Dean, A. W. Detcher, W. H. Dunfield, D. A. Durrant, J. A. Erskine, B. M. Evans, J. Fabi, R. D. Farrell, W. E. Fellner, C. M. Fraser, M. J. Fredericks, M. J. Fulham, D. W. Gidley, J. R. Grace, D. G. Gratton. S. J. Gyorffy, H. Hassan, L. D. Holmes, D. K. Jacobs, J. W. Jardine, H. W. Jennerich, R. W. Kuntz, J. D. Lindsay, B. Lock. A. W. MacKenzie, J. E. Marsh, B. E. McCarney, C. McCormick, D. McLeod, D. P. Morris, B. L. Mozina, A. J. Nusca. J. R. Nusca, F. Oille, S. Panajotow, J. C. Pooley, J. Post, K. M. Rainford, K. O. Raycraft, A. Rezebergs, R. L. Rochester, D. Schebesch, G. Schurman, P. E. Sharpe, W. H. A. Sheldon, M. Sinclair, J. E. Stark, N. H. Stone, W. Trick, G. J. ven den Broek, W. J. van den Hengel, J. Van Koughnett, V. Vitkauskas, J. Weil, G. Weisz, H. Wertli, P. S. Wilker, G. E. Williams, W. J. Williams, B. Zechel.

University of New Brunswick:
L. A. Ashfield, F. A. Blanchard, F. Boudreau, R. J. Bourdage, C. B. D. Bunner, G. T. Calkin, C. H. Chu, R. D. Clark, D. C. Colpitts, D. P. De Merchant, C. A. Edie, P. C. Ellis, D. A. Flanagan, A. F. Fowler, J. L. Goddard, E. G. Graham, E. G. B. Graham, J. G. Greenough, G. T. J. Henderson, K. R. Higson, H. A. Janson, D. W. Johnston, M. R. Johnston, T. M. Keddy, K. K. C. Kwong, E. H. J. Lane, P. A. Leger, O. J. Lemon. R. M. Levasseur, G. A. Levesque, J. W. Lutz, V. E. McAllister, G. P. Marcotte, G. G. Marks, E. I. McClure, R. D. McFee, R. H. McLean, D. T. Morrow, D. J. H. Mulholland, D. J. Murfin, R. Noseworthy, J. D. O'Blenis, M. Y. Papillon, P. A. Parker, S. Ronen, E. J. Ryan, F. W. P. Selby, F. E. Smith, W. A. Smith, P. K. Stangeland, M. J. Steeves, C. J. Stein, D. L. Sullivan, R. P. Tapper, G. E. Tripp, G. M. A. Vail, H. A. Warnock, W. B. Wasson, A. Y. B. Wong, K. W. Wong, R. A. Wood.

University of Alberta:
D. T. Alexander, D. J. Blakeman, A. A. Brown, J. R. Chase, M. G. Faulkner, W. E. Germaniuk, D. A. Grant, J. C. Gunn, W. W. Haigh, J. N. Heffernan, T. F. Homeniuk, J. W. Jensen, C. R. Kirby, D. E. Lauckner, T. B. McFadzean, B. A. McGregor, R. A. Nobbs, W. E. Nysetvold, J. B. Osenton, M. H. Porter, B. Quam, E. S. Rybinski, D. J. Saxby, D. Scholtz, J. A. Spankie, B. E. Swan, A. Taskinen, T. C. Thom, L. R. Thompson, N. L. Tozer, D. J. Umrysh, M. W. Weber, R. C. Westendorf, R. D. Wohl, R. D. Yarmchuk.

University of Ottawa:
G. G. Beaudry, D. F. Callan, V. Caloia, R. A. Chapman, D. A. Clark, S. Courchesne, R. Fournier, A. Gouin, J. A. F. Guindon, W. J. Kasowski, F. D. MacLeod, J. W. McLewin, J. Paul-Hus, J. J. G. Potvin, R. J. Prud'homme, D. Rivest, N. J. Roy, R. St. Amour, J. Vaucher, K. H. Weissert.

St. Dunstan's University:
J. E. Arsenault, F. J. Callaghan, M. Campbell, J. W. Carswell, G. Chan, J. Gillis, R. J. Gondek, C. Keating, R. E. Labonte, A. Lopez, C. MacIsaac, N. J. MacLauchlan, D. T. Mahoney, J. Marchand, J. C. McCardle, D. F. McNally, H. J. Murphy, R. E. Pederson, M. V. Power, J. L. Praught, B. I. Rayner, F. C. Wedge.

Loyola College:
G. L. Barletti, J. A. J. Bertrand, A. L. Brosseau, R. E. Carrick, S. S. W. Chan, D. O. T. Choquette, D. J. Clarke, C. R. Cooper, K. J. Coulter, D. J. G. de Verteuil, M. J. Durand, G. Fabi, B. F. Gareau, B. Gargano, A. G. Simon C., R. D. Gladu, F. E. Hamilton, R. N. Haydon, W. A. Horne, F. Iezzoni, G. J. Ikin, E. J. Knystautas, C. F. Kohler, J. Lukosevicius, R. A. Marleau, R. D. Martin, R. H. M. Michels, N. W. L. Murphy, L. L. O'Connell, B. T. O'Connor, G. Parkin, A. Petrauskis, J. M. Piment, A. Pina, R. Santo, J. R. Vinette.

Royal Military College:
J. C. Beacham, J. W. Crawford, D. W. Edgecombe, S. G. Esdaile, W. G. H. Evans, E. A. Everest, J. A. Jackson, F. E. Jewsbury, R. B. Manning, M. C. McGregor, J. L. Richard, J. D. Sutherland, E. A. Wehrle.

University of Toronto:
E. N. Aplin, R. C. Davis, C. de Wit, J. W. Goodanetz, K. Lovinsky, R. N. MacKay, J. A. McLaren, A. Niiholm, J. Thurner, R. C. Tze.

Carleton University:
A. W. Andrews, J. E. Barnes, N. H. Fyfe, G. A. Lavoie, M. H. Quast, A. G. Ross, R. M. Solman, P. B. Wright.

St. Joseph's University:
G. Couturier, R. Dugas, J. G. Leblanc, J. G. Nadeau.

Michigan College of Mining and Technology: C. E. Mickelson, T. G. Bullock.

Mount Allison University: J. E. Stevens.

Ontario Agricultural College: C. E. Pritchard.

Royal College of Science and Technology: Ka-Pang Hsu.

Applications through Associations

By virtue of the co-operative agreements between the Institute and the Associations the following elections and trans-

(Continued on page 80)

REGISTRATION IN ENGINEERING AT CANADIAN UNIVERSITIES 1961-62

University	Year	General Course	Agricultural Engineering	Petroleum Engineering	Chemical Engineering	Civil Engineering	Electrical Engineering	Industrial Engineering	Geology and Mineralogy Engineering	Mechanical Engineering	Metallurgical Engineering	Mining Engineering	Engineering Physics	Surveying Engineering	Forest Engineering	Total
Memorial	1st	83	....	....	....	....	....	....	....	....	....	....	....	....	..	83
	2nd	44	....	....	....	....	....	....	....	....	....	....	....	....	..	44
	3rd	56	....	....	....	....	....	....	....	....	....	....	....	....	..	56
Total...........		183	....	....	....	....	....	....	....	....	....	....	....	....	..	183
Dalhousie	1st	70	....	....	....	....	....	....	....	....	....	....	8	....	..	78
	2nd	87	....	....	....	....	....	....	....	....	....	....	5	....	..	92
	3rd	37	....	....	....	....	....	....	....	....	....	....	7	....	..	44
	4th	....	....	....	....	....	....	....	....	....	....	....	4	....	..	4
	5th	....	....	....	....	....	....	....	....	....	....	....	7	....	..	7
Total...........		194	....	....	....	....	....	....	....	....	....	....	31	....	..	225
St. Mary's	1st	58	....	....	....	....	....	....	....	....	....	....	....	....	..	58
	2nd	24	....	....	....	....	....	....	....	....	....	....	....	....	..	24
	3rd	22	....	....	....	....	....	....	....	....	....	....	....	....	..	22
Total...........		104	....	....	....	....	....	....	....	....	....	....	....	....	..	104
St. Francis Xavier	1st	59	....	....	....	....	....	....	....	....	....	....	....	....	..	59
	2nd	61	....	....	....	....	....	....	....	....	....	....	....	....	..	61
	3rd	42	....	....	....	....	....	....	....	....	....	....	....	....	..	42
Total...........		162	....	....	....	....	....	....	....	....	....	....	....	....	..	162
N.S. Technical College	4th	....	....	....	9	72	57	....	....	50	5	6	....	....	..	199
	5th	....	....	....	13	39	32	....	....	23	7	2	....	....	..	116
Total...........		....	....	....	22	111	89	....	....	73	12	8	....	....	..	315
Acadia	1st	63	....	....	....	....	....	....	....	....	....	....	....	....	..	63
	2nd	39	....	....	....	....	....	....	....	....	....	....	....	....	..	39
	3rd	27	....	....	....	....	....	....	....	....	....	....	....	....	..	27
Total...........		129	....	....	....	....	....	....	....	....	....	....	....	....	..	129
Mount Allison	1st	56	....	....	....	....	....	....	....	....	....	....	....	....	..	56
	2nd	48	....	....	....	....	....	....	....	....	....	....	....	....	..	48
	3rd	32	....	....	....	....	....	....	....	....	....	....	....	....	..	32
Total...........		136	....	....	....	....	....	....	....	....	....	....	....	....	..	136
New Brunswick	1st	....	....	....	22	49	51	....	....	36	....	3	....	3	..	164
	2nd	....	....	....	15	55	34	....	....	29	....	1	....	4	..	138
	3rd	....	....	....	9	43	48	....	....	24	....	1	....	2	..	127
	4th	....	....	....	9	51	26	....	....	32	....	....	....	7	..	125
	5th	....	....	....	5	50	31	....	....	14	....	....	....	4	..	104
Total...........		....	....	....	60	248	190	....	....	135	....	5	....	20	..	658
St. Joseph's	1st	27	....	....	....	....	....	....	....	....	....	...	....	...		27
	2nd	21	....	....	....	....	....	....	....	....	....	...	....	...		21
	3rd	9	....	....	....	....	....	....	....	....	....	...	....	...		9
Total...........		57	....	....	....	....	....	....	....	....	...	...	....	....	.	57
Laval	1st	275	....	....	....	....	....		....	....						275
	2nd	271	....	....	....	....	....		....	....					.	271
	3rd	....	....	....	11	10	59		3	29	10	4	19			175
	4th	....	....	....	13	17	21		2	26	7	2	6			127
	5th	....	....	....	4	51	19		3	18	2	4	5			106
Total...........		546	....	....	28	138	102		8	73	19	10	30			954
Ecole Polytechnique	1st	258	...	....	...	.			...	....	.	..	.			258
	2nd	329	....	...	...	..			...	....			..			329
	3rd	295	...	...	...		.		...	...		.	..			295
	4th	....	....	...	20	85	61		4	65	11	8	11			265
	5th	...	...	...	12	106	50		2	51	13	22	15	.		271
Total...........		882	...	....	32	191	111		6	116	24	30	26			1,418
McGill	1st	270	....	...	...	..	.									270
	2nd	233	...	...	...	..										233
	3rd	....	....	...	25	44	58			50	10	4	15			206
	4th	....	....	...	15	51	71			41	3	3	7			194
	5th	....	....	...	24	71	110			45	8	1	2			261
Total...........		503	..	.	64	166	242			136	21	8	24			1,164

REGISTRATION IN ENGINEERING AT CANADIAN UNIVERSITIES 1961-62

University	Year	General Course	Agricultural Engineering	Petroleum Engineering	Chemical Engineering	Civil Engineering	Electrical Engineering	Industrial Engineering	Geology and Mineralogy Engineering	Mechanical Engineering	Metallurgical Engineering	Mining Engineering	Engineering Physics	Surveying Engineering	Forest Engineering	Total
Sir George Williams	1st	140	....	....	....	....	....	....	....	....	....	....	....	....	..	140
	2nd	98	....	....	....	....	....	....	....	....	....	....	....	....	..	98
	3rd	....	....	....	6	6	17	....	....	5	....	....	....	....	..	34
Total		238	....	....	6	6	17	....	....	5	....	....	....	....	..	272
Loyola	1st	75	....	....	....	....	....	....	....	....	....	....	....	....	..	75
	2nd	58	....	....	....	....	....	....	....	....	....	....	....	....	..	58
	3rd	....	....	....	2	15	7	....	....	16	....	....	1	....	..	41
Total		133	....	....	2	15	7	....	....	16	....	....	1	....	..	174
Sherbrooke	1st	82	....	....	....	....	....	....	....	....	....	....	....	....	..	82
	2nd	54	....	....	....	....	....	....	....	....	....	....	....	....	..	54
	3rd	34	....	....	....	....	....	....	....	....	....	....	....	....	..	34
	4th	....	....	....	....	10	14	....	....	6	....	....	....	....	..	30
	5th	....	....	....	....	17	13	....	....	9	....	....	....	....	..	39
Total		170	....	....	....	27	27	....	....	15	....	....	....	....	..	239
Ottawa	1st	62	....	....	1	13	19	....	....	....	....	....	....	....	..	95
	2nd	60	....	....	7	12	22	....	....	....	....	....	....	....	..	101
	3rd	3	....	....	10	12	21	....	....	....	....	....	....	....	..	46
	4th	2	....	....	10	....	19	....	....	....	....	....	....	....	..	31
	5th	....	....	....	6	....	11	....	....	....	....	....	....	....	..	17
Total		127	....	....	34	37	92	....	....	....	....	....	....	....	..	290
Carleton	1st	67	....	....	....	....	....	....	....	....	....	....	....	....	..	67
	2nd	30	....	....	....	....	....	....	....	....	....	....	....	....	..	30
	3rd	36	....	....	....	....	....	....	....	....	....	....	....	....	..	36
	4th	....	....	....	....	8	7	....	....	10	....	....	2	....	..	27
Total		133	....	....	....	8	7	....	....	10	....	....	2	....	..	160
Queen's	1st	245	....	....	....	....	....	....	....	....	....	....	....	....	..	245
	2nd	....	....	....	17	44	28	....	9	42	13	8	22	....	..	183
	3rd	....	....	....	13	35	40	....	14	26	12	7	21	....	..	168
	4th	....	....	....	21	38	32	....	9	43	7	4	27	....	..	181
Total		245	....	....	51	117	100	....	32	111	32	19	70	....	..	777
Toronto	1st	....	....	....	71	82	72	19	14	33	11	13	100	....	..	415
	2nd	....	....	....	56	43	66	27	5	43	11	1	71	....	..	323
	3rd	....	....	....	57	54	68	18	5	67	11	6	65	....	..	351
	4th	....	....	....	48	67	69	32	11	70	7	14	81	....	..	399
Total		....	....	....	232	246	275	96	35	213	40	34	317	....	..	1,488
McMaster	1st	81	....	....	....	....	....	....	....	....	....	....	....	....	..	81
	2nd	....	....	....	13	10	14	....	....	12	4	....	8	....	..	61
	3rd	....	....	....	7	5	11	....	....	9	2	....	3	....	..	37
	4th	....	....	....	7	....	10	....	....	7	1	....	4	....	..	29
Total		81	....	....	27	15	35	....	....	28	7	....	15	....	..	208
Ontario Agricultural College	2nd	30	....	....	....	....	....	....	....	....	....	....	....	....	..	30
	3rd	....	....	....	....	5	....	....	....	12	....	....	....	....	..	17
	4th	....	....	....	....	11	....	....	....	7	....	....	....	....	..	18
Total		30	....	....	....	16	....	....	....	19	....	....	....	....	..	65
Waterloo**	1st	316	....	....	....	....	....	....	....	....	....	....	....	....	..	316
	2nd	....	....	....	33	43	48	....	....	56	....	....	10	....	..	190
	3rd	....	....	....	16	27	35	....	....	33	....	....	14	....	..	125
	4th	....	....	....	13	31	26	....	....	30	....	....	13	....	..	113
	5th	....	....	....	13	22	6	....	....	15	....	....	16	....	..	72
Total		316	....	....	75	123	115	....	....	134	....	....	53	....	..	816
Western Ontario	1st	100	....	....	....	....	....	....	....	....	....	....	....	....	..	100
	2nd	68	....	....	....	....	....	....	....	....	....	....	....	....	..	68
	3rd	....	....	....	7	7	14	....	....	9	....	....	....	....	..	37
	4th	....	....	....	3	9	3	....	....	8	....	....	....	....	..	23
Total		168	....	....	10	16	17	....	....	17	....	....	....	....	..	228

REGISTRATION IN ENGINEERING AT CANADIAN UNIVERSITIES 1961-62

University	Year	General Course	Agricultural Engineering	Petroleum Engineering	Chemical Engineering	Civil Engineering	Electrical Engineering	Industrial Engineering	Geology and Mineralogy Engineering	Mechanical Engineering	Metallurgical Engineering	Mining Engineering	Engineering Physics	Surveying Engineering	Forest Engineering	Total
Assumption	1st	31	....	....	8	16	12	....	....	6	....	....	3	....	..	76
	2nd	....	....	....	7	9	21	....	....	3	....	....	7	....	..	47
	3rd	....	....	....	7	10	12	....	....	6	....	....	....	....	..	35
	4th	....	....	....	3	17	11	....	....	1	....	....	....	....	..	32
Total..........		31	....	....	25	52	56	....	....	16	....	....	10	....	..	190
Laurentian	1st	16	....	....	....	....	....	....	....	....	....	....	....	....	..	16
Total..........		16	....	....	....	....	....	....	....	....	....	....	....	....	..	16
Manitoba	1st	254	....	....	....	....	....	....	....	....	....	....	....	....	..	254
	2nd	150	....	....	....	....	....	....	1	....	....	....	6	....	..	157
	3rd	....	....	....	....	43	47	....	1	23	....	....	4	....	..	118
	4th	....	....	....	....	58	42	....	1	35	....	....	5	....	..	141
Total..........		404	....	....	....	101	89	....	3	58	....	....	15	....	..	670
Saskatchewan	1st	381	....	....	....	....	....	....	....	....	....	....	....	....	..	381
	2nd	186	2	1	19	....	14	....	10	2	....	....	11	....	..	245
	3rd	....	18	....	11	58	35	....	13	51	....	....	15	....	..	201
	4th	....	17	2	15	66	49	....	13	42	....	....	24	....	..	228
Total..........		567	37	3	45	124	98	....	36	95	....	....	50	....	..	1,055
Alberta (Edmonton)	1st	236	....	....	....	....	....	....	....	....	....	....	....	....	..	236
	2nd	....	....	2	32	60	69	....	....	47	9	1	....	....	..	220
	3rd	....	....	6	26	70	48	....	....	39	7	3	7	....	..	206
	4th	....	....	6	37	73	82	....	....	34	8	2	11	....	..	253
Total..........		236	....	14	95	203	199	....	....	120	24	6	18	....	..	915
Alberta (Calgary)	1st	102	....	....	....	....	....	....	....	....	....	....	....	....	..	102
	2nd	....	....	....	18	14	18	....	....	9	....	....	....	....	..	59
Total..........		102	....	....	18	14	18	....	....	9	....	....	....	....	..	161
British Columbia	1st	327	....	....	....	....	....	....	....	....	....	....	....	....	..	327
	2nd	245	....	....	....	....	....	....	....	....	....	....	....	....	..	245
	3rd	....	....	....	26	40	54	....	11	41	20	5	11	....	2	210
	4th	....	....	....	26	40	53	....	11	47	25	3	14	....	..	219
Total..........		572	....	....	52	80	107	....	22	88	45	8	25	....	2	1,001
Canadian Services Colleges																
Royal Military College (Kingston)	1st	77	....	....	....	....	....	....	....	....	....	....	....	....	.	77
	2nd	39	....	....	....	....	....	....	....	....	....		....	....	.	39
	3rd	....	....	....	7	19	25	....	....	25	....	....	8	....	.	84
	4th	....	....	....	6	28	13	....	....	15	....	.	3	.	.	65
Total..........		116	....	....	13	47	38	....	....	40	..		11			265
Royal Roads	1st	96	....	....	..	....	....	....	....	..	.	...	.	...		96
	2nd	17	....	....	5	17	16	....	..	4		...	18	..		77
Total..........		113	....	....	5	17	16	....	..	4			18			173
College Militaire Royal de St.-Jean	1st	146	.	..	..	.	.	.						.		146
	2nd	76	..	....		.	.							.		76
Total..........		222	....	....	.			.								222
Grand Total......		6,916	37	17	896	2,118	2,017	96	142	1,531	224	128	716	20	2	14,890
Prospective 1962 Graduates		..	17	8	213	760	613	32	50	487	78	52	216	4		2,590

**Figures shown are for the Co-operative Engineering course and represent combined enrolment of Fall 1961 and Winter 1962 (est

(Continued from page 76)

fers became effective October 28, 1961.

ALBERTA

Associate Members: B. E. B. Cameron, R. R. Coutts.

Associate Member to Member: H. D. Meley.

SASKATCHEWAN

Members: R. Agarwal, R. L. Hansen, J. F. Zimmerman.

Associate Members: J. S. Ink, J. F. Kopchynski, A. Krchmar.

Associate Member to Member: J. M. Heidt, A. Lissey, A. D. Newsham, R. G. Sanders, A. T. Torgrimson.

NEW BRUNSWICK

Member: P. R. Stewart.

Report of the Admissions Committee November 25, 1961

STUDENTS ADMITTED

Dalhousie University:
D. G. Alexander, H. P. Blois, J. S. Collins, J. W. Cowie, F. W. Cullen, W. E. Ellis, C. A. Firth, P. B. Forrest, D. L. George, M. J. Giddy, B. W. Green, K. E. Hutchinson, H. Jansen, R. E. Johnson, J. R. Lord, I. S. MacDonald, R. D. MacKeen, D. G. Maclean, D. K. Maclean, S. A. Malcolm, J. T. Manuel, P. F. Martin, M. Mayall, C. S. L. MacNeil, T. B. Meisner, J. B. Mitchell, G. D. Murray, A. G. Nauss, P. P. Nickerson, T. G. O'Flaherty, T. L. Pierce, G. C. Read, A. J. Robertson, H. E. Sangster, H. Y. K. Wong, H. C. Wood, R. A. Woodroffe.

Laval University:
J. Archambault, Y. Armstrong, L. Aubin, J. Beaulieu, P. A. Belanger, P. A. Blanchet, J. Brunet, G. Couillard, R. Doucet, J. C. Dufour, B. Fradet, A. Gauvin, C. Laliberte, G. Laperriere, J. C. Lavoie, P. Lavoie, G. Lessard, J. Lortie, H. Marois, R. Noiseux, A. Nollet, C. Ouellet, J. Y. Ouellet, A. Pellan, D. Pomerleau, J. G. G. Porlier, D. W. Seale, G. Tanguay, L. Tanguay, A. Tremblay, G. Trudel, J. P. Villeneuve.

Canadian Services College—Royal Roads:
B. W. Ailey, R. G. Bell, R. W. Boadway, F. G. Bobiasz, R. Boylo, J. E. Bradbury, R. O. P. Brown, T. C. Calow, T. F. Cawsey, G. A. Cooper, D. C. Draper, L. G. Dube, P. J. Dunne, H. A. Gordon, H. M. Griffiths, C. R. Keple, J. T. Koziel, A. D. Lee, J. G. Leech, W. P. Marshall, W. D. McNeill, G. Mulder, D. G. Oke, J. H. Racine, D. A. Renshaw, M. E. Ronberg, R. A. Row, J. M. Saunders, W. R. Scott, G. E. Spence, D. C. Summers, W. S. Yankowich.

University of New Brunswick:
J. H. Arbing, H. F. Bamford, J. A. G. Booth, H. K. Campbell, G. V. Craswell, D. C. De Merchant, G. S. Gorham, M. Horn, J. B. Mercer, D. K. Misener, F. A. Sainz, N. S. Slover, A. K. L. Wong.

University of Alberta:
W. J. Chudobiak, J. F. Hugo, R. J. Hunter, N. H. Neufeld, L. W. Sadler, W. G. Seyer, R. E. Stauffer, C. D. Westcott.

Loyola College:
K. C. Kelly, M. E. Malone, S. Marino, S. Peres, N. Preston, J. Seliskar, S. Sopko.

University of Western Ontario:
J. R. Archer, M. K. Dick, J. R. De Koning, D. L. Denomy, P. Howe, M. Jensen, K. A. Smart.

University of Toronto:
W. R. Buckley, W. T. Dickinson, I. A. Fraser, R. W. Jones, F. S. Martin, S. Masionis.

Ontario Agricultural College:
R. J. Burnside, W. J. Harrison, G. S. Messenger, E. R. Norris, D. G. Weldon.

McGill University:
R. A. Knebel, J. F. Milton, D. S. Thiara, R. S. Trump, M. R. Vadori.

St. Joseph University:
C. Bourgeois, D. Drapeau, J. Guimond, J. A. LeBlanc, G. Savoie, O. Vautour.

University of Ottawa:
J. Auns, J. Boucher, S. H. Van Eyk, M. Voyer.

McMaster University:
S. W. Broadbridge, D. P. Holmberg.

Application through Associations

By virtue of the co-operative agreements between the Institute and the Associations the following elections and transfers became effective November 25, 1961.

ALBERTA

Associate Member: D. K. McJunkin.

Associate Member to Member: R. S. Thomson.

SASKATCHEWAN

Members: M. H. Allan, A. J. Balezantis, J. P. Earl, W. H. Griffin, C. E. Kules, K. Mountain, J. O. Pitts, P. A. Utley, D. E. Wahler.

Associate Members: J. C. Badger, G. E. Dubord.

Student: E. A. George.

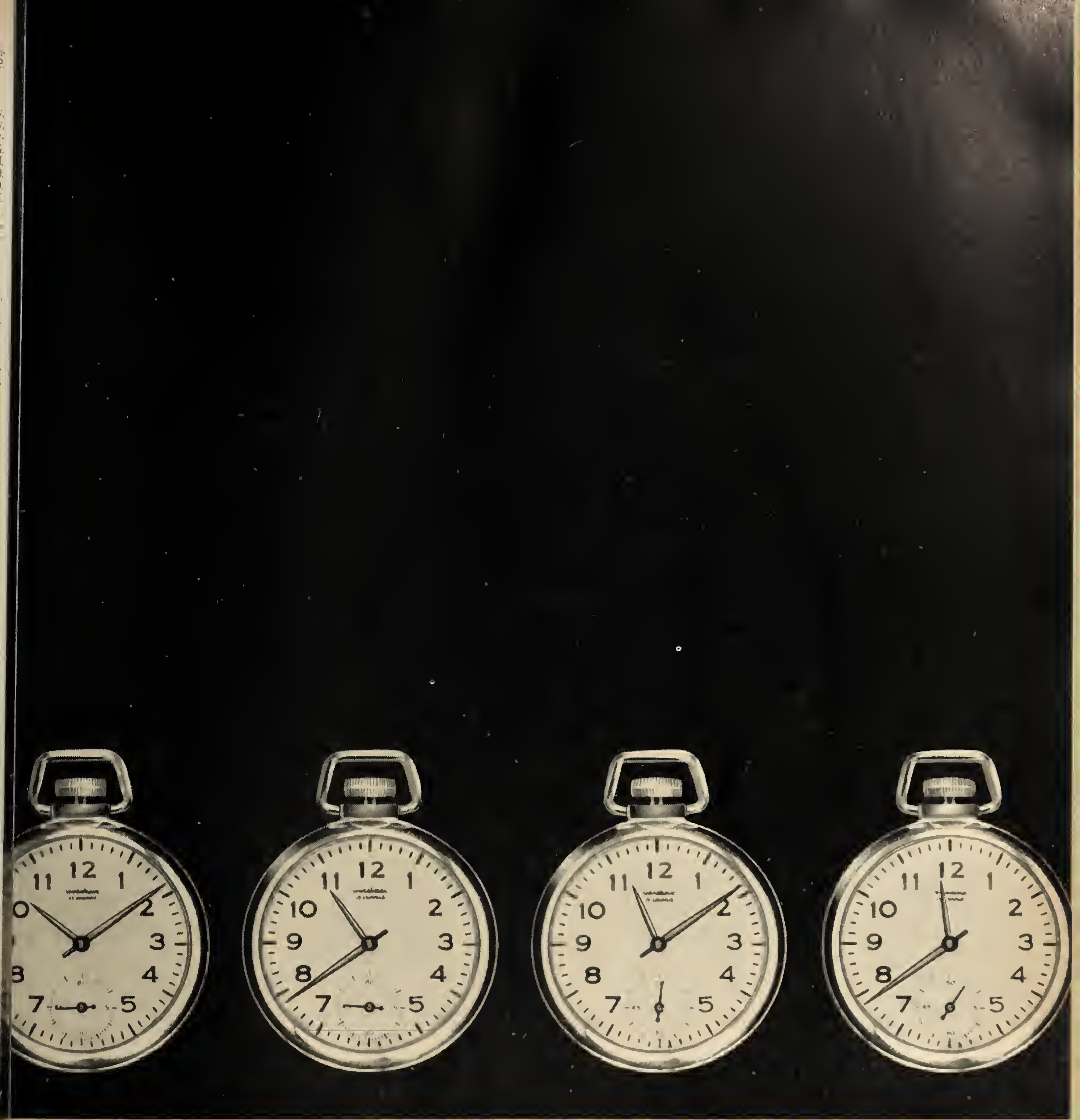
Associate Member to Member: R. K. Broeder, P. E. Brown, J. J. Luchanko, L. E. Stanley, L. B. Sylvester.

NOVA SCOTIA

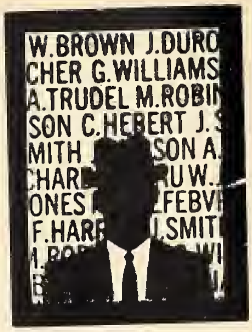
Member: R. C. Rushton.

ERRATA

On page 124 of the October issue of the Engineering Journal it was reported in error in the minutes of the 1961 Annual General Meeting that "Professor Black said he would support the senior members who have urged that the Institute proceed slowly with this matter." This should have read: "Professor Lash said he would . . ." The Journal regrets any embarassment this error might have caused.



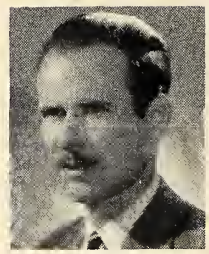
Personals




H. L. Johnston, M.E.I.C.


L. W. Pillar, M.E.I.C.


R. E. Grout, M.E.I.C.


G. P. Webb, M.E.I.C.

H. Lloyd Johnston, M.E.I.C. (McGill '27) recently retired from his position as Chief Engineer with Du Pont of Canada Ltd. He joined the Company in 1936 as project engineer. Since then, he has held a number of senior posts, including that of manager at a plant at Windsor, Ont. He was appointed Chief Engineer in 1954. Immediately following retirement he entered private practice and is now engaged on a two year assignment with E. I. du Pont de Nemours & Company as a consultant. Part of his time is spent in Los Angeles and part in Mexico.

L. W. Pillar, M.E.I.C. (King's College '25) was appointed recently to the board of directors of Ewbank, Tupper & Associates Ltd. in the recent reorganization and change in name and ownership of that company. Mr. Pillar, who was vice-president of Ewbank & Partners (Canada) Ltd. will, besides serving as a director of Ewbank, Tupper and Associates, also hold the position of executive vice-president and will be in charge of civil engineering with the new Canadian company. Prior to this Mr. Pillar was a consultant in charge of major highway and public works projects in Ontario.

R. P. Horlock, M.E.I.C. (City & Guilds '28), director and vice-president of Associated Electrical Industries (Canada) Ltd., recently transferred to the head office of AEI Ltd., London, England. He will retain his present position, and in addition be manager, North American Area, for AEI Export Ltd.

A. J. Leighton, M.E.I.C. (U. of Sask. '42) has been named a vice-president of the consulting engineering firm, Ingledow Kidd & Associates Ltd. Until recently Mr. Leighton was a vice-president of International Power and Engineering Consultants and was formerly Director of Engineering of the B.C. Power Commission.

R. E. Grout, M.E.I.C. (Alberta '36) has been appointed president of The Shawinigan Engineering Company, Limited. Formerly vice-president, Engineering, Mr. Crout succeeds Guy R. Rinfret who died recently. He joined Shawinigan Engineering in 1937 as a junior engineer. He was in charge of the electrical design for a number of the Company's developments and others for which the Company has done design work. He was appointed senior eleetrical engineer in 1954, chief engineer, Electrical division, in 1956, a director and vice-president in 1960, and vice-president, Engineering, in 1961.

Geoffrey P. Webb, M.E.I.C. (London '52) has accepted an administrative position with the Frequency Standardization Commission of the Electricity Authority of Jamaica, and has taken up residence in Kingston. For the past five years Mr. Webb has been engaged in the design of Hydro-Quebec's Bersimis II Project and their Carillon development on the Ottawa River.

R. C. Beal, M.E.I.C. (Tor. '44) has been appointed manager of engineering at The British American Oil Company's head office in Toronto. Mr. Beal was formerly chief engineer.

J. A. Thomas, M.E.I.C. (Queen's '42) has been appointed a director and vice-president, Engineering, of The Shawinigan Engineering Company, Limited. Mr. Thomas joined Shawinigan Engineering in 1948 and soon after was named hydraulic engineer. In 1954 he was appointed hydraulic engineer in charge of civil engineering design. In 1956, he was appointed chief engineer, Civil division, and vice-president in March of 1961.

Mark W. Booth, M.E.I.C. (London University '10) recently retired after 51 years' service with the Dominion Steel and Coal Corporation Limited's plant at Sydney, Nova Scotia. Mr. Booth was made a life member of E.I.C. a few months ago.

Karl Glackmeyer, A.M.E.I.C. (Loyola College) has been appointed Quebec representative of Canadian Aero Service Quebec Ltd.

A. J. Kyle, M.E.I.C. (U.B.C. '51) has been appointed Underground Superintendent at the potash mine and plant project of International Minerals & Chemical Corp. (Canada) Ltd. Prior to joining IMC, Mr. Kyle worked with the Potash Company of America Ltd., at Saskatoon, and Stanrock Uranium Mines at Elliott Lake, Ont. In his new post he will be responsible for the engineering and selection of equipment, supervising, planning and scheduling of the underground operation.

Andrew J. Watt, M.E.I.C., of Fairvale, King's County, N.B., has established his own consulting firm and will specialize in the design and detail of structures and serve as a representative for engineering goods and specialties in the Maritimes. Mr. Watt recently resigned his position with the Saint John Shipbuilding and Dry Dock Co. Ltd. where he was director of personnel and training.

J. L. Halter, M.E.I.C. (U. of Man. '46) has been appointed superintendent of engineering of the Red Rock Mill of St. Lawrence Corporation Ltd. Prior to this promotion Mr. Halter was plant engineer at the same Mill.

Evar Y. Carlson, M.E.I.C. (Sask. '50) has been appointed manager, Product Planning, of the Canada Brick Division of Canadian-Marietta of Ontario Limited. Mr. Carlson was formerly General Manager of Saskatchewan Clay Products.

Obituaries

E. H. Darling, M.E.I.C., and a life member of E.I.C. died Aug. 23, 1961. Mr. Darling graduated from the University of Toronto in mechanical engineering in 1898. He became an associate member of E.I.C. in 1904, a member in 1919 and was made a life member in 1947.

Other Societies

United Engineering Center Opens

The official opening of the 20-storey United Engineering Center, New York, took place early in November. The building currently houses 19 professional groups, representing some 300,000 engineers.

The Center, located on the United Nations Plaza, has been constructed at a cost of about $12 million. Much of the money has come from the contributions of individual engineers, augmented by gifts from industry.

Funds were raised for the building—and its overall planning and construction supervised—by the United Engineering Trustees, Inc. This control group was entrusted in 1904 to administer the old Engineering Societies Building and has continued since to control the jointly owned and operated facilities as the building and the Engineering Societies Library.

The $800,000 quota assigned to the American Society of Civil Engineers, with a membership of about 48,000, for the building fund was raised by co-operation of all the Sections, their Branches and many of the Student Chapters. Money was received from engineers in a number of other countries.

The United Engineering Center will open a new era to the engineering societies and their headquarters staffs. The move will bring into a central building five groups that were not in the Engineering Societies Building. For the first time the societies will have lunching facilities within their own building, thus bringing their staffs into daily contact. Also the building will provide a convenient meeting place for visiting engineers.

Former President Herbert Hoover

Initially the Engineering Foundation department of the United Engineering Trustees, Inc. was established for the furtherance of research in science and engineering. Later, the Foundation turned from the support of research to the stimulation of research. Today's program is directed to a greater utilization of the mental energies and capacities of the five Founder Societies represented by United Engineering Trustees, and which have an aggregate membership of over 200,000. The Engineering Foundation, through this great resource, seeks to be a more effective joint instrumentality than ever in the service of these Societies within their broad interrelated areas.

The Founder Societies are the American Society of Civil Engineers, the American Institute of Mining, Metallurgical, and Petroleum Engineers, The American Society of Mechanical Engineers, the American Institute of Electrical Engineers, and the American Institute of Chemical Engineers.

Prime Minister Diefenbaker sent a message stating: "On behalf of the Government of Canada I extend greetings and congratulations on the occasion of the dedication of the United Engineering Center. The Center will prove of invaluable service in many national and international endeavours to engineers in Canada and the U.S.A. who have developed over the years an outstanding relationship of co-operation and mutual assistance."

A message from President Kennedy at the dedication ceremonies read in part, "It is perhaps significant that in this era, when the mind of man is the basis for world struggle, we find a considerable measure of hope in the technological strengths our engineers can share with peoples of the free world. Without the technological developments that have taken place in our country, which have provided us with the resources to maintain our life as we know it, ours would be an uncertain future."

Among those who spoke at the dedication of the Center were: former President Herbert Hoover; Robert P. Wagner, Mayor of New York; S. W. Marras, Secretary and General Manager of the United Engineering Trustees, Inc.; William Hallerberg, an engineering student from Missouri School of Mines and Metallurgy, Rolla, Mo.

Representing the Engineering Institute of Canada were: President B. G. Ballard; Past-President L. F. Grant of Kingston, Ont.; and General Secretary, G. T. Page.

Industrial Relations Proceedings

"Changing Patterns in Industrial Relations", the Proceedings of the 13th annual industrial relations conference at McGill University, now is available. The program of the 1961 conference held last June was concerned primarily with the effects of technological and scientific change on industrial relations—particularly those identified with automation.

The Proceedings are available at the Industrial Relations Centre, McGill University, 1020 Pine Ave. W., Montreal 2. Price per copy post paid is $2. Four or more copies, each $1.80.

Coming Events

American Society of Heating, Refrigerating and Air Conditioning Engineers. Semi-annual Meeting. St. Louis. Jan. 28-Feb. 1.

American Institute of Electrical Engineers. Winter General Meeting. New York City. Jan. 29-Feb. 2.

Canadian Institute of Surveying and Photogrammetry. Annual Meeting. Ottawa. Feb. 7-9.

American Institute of Mining, Metallurgical and Petroleum Engineers Inc. Annual Meeting. New York City. Feb. 18-22.

American Society of Civil Engineers. Houston, Texas. Feb. 19-23.

American Society of Mechanical Engineers. Gas Turbine Power Conference. Cleveland. March 4-7.

Engineering Institute of Canada, Montreal Branch. Urban Transportation Conference. Montreal. March 22-23.

ASME-AIEE-EIC Railway Conference. Toronto. April 9-11.

Engineering Institute of Canada. Southern Ontario Regional Technical Conference. London, Ont. April 28.

Engineering Institute of Canada. Annual Meeting. Montreal. June 12-15. EIC

News of the Branches

Amherst

G. C. L. McEnery, M.E.I.C.
Correspondent

At the November 24 meeting at the Cumberland Hotel, speaker Herb Marshall, Past Chairman of the Halifax Branch, was introduced by W. D. Hagan, Chairman of the Amherst Branch. Mr. Marshall was the initial speaker in a series of lectures to familiarize the members on the subject of Confederation. He touched briefly on the history of the E.I.C., and spoke at length on the information services, committee work, and other services offered by the E.I.C. to its members. A vote of thanks was given by J. W. Wilson, Councillor for the Amherst Branch. The Chairman and members of the Branch agreed that the subject of Confederation is a vital one and careful study and consideration should be given it before the Branch voices its opinion to the national body.

Baie Comeau

G. W. Scott, M.E.I.C.
Correspondent

Forty-three members and affiliates were present at the November 16 meeting of the Branch, at which Dr. Peter Millman, head of upper atmosphere research at the National Research Council, was guest speaker.

Dr. Millman's interesting two hour address entitled "The A.B.C. of Space Travel", was supported by an excellent series of slides including photographs, diagrams and striking color sketches. It gave a comprehensive picture of space investigation, both historical and of what we may expect to see in the near future. Starting humorously, with the imaginative flights of fancy into space of the 18th century's Baron Munchausen, Dr. Millman briefly traced the development and history of rocketry up to the German V2 project during World War II. In greater detail, he then outlined the work carried out by the United States in the development of the multi-stage rockets necessary for the space probes, up to the successful launching of the Saturn C1 on October 27, 1961. Future developments of man-in-space projects would, according to Dr. Millman, largely depend on the Saturn C4 rocket, an improved model of the C1 with a total thrust of 6,000,000 lb. Some idea of the progress in design of rockets can be appreciated from the fact that the German V2 on which the United States and the Soviet Union based their initial development programs after World War II, had a thrust of only 56,000 lb. It is anticipated that the Saturn will have sufficient capacity to launch a three-man vehicle into space.

Dr. Millman also presented a brief competitive analysis of the United States and Russian space efforts, stressing the difference in overall policy and economic resources made available in each case. In development immediately after the war, the United States space administration did not have the funds made available to them for the development of the large rocketry necessary for man-in-space projects. The Russians had concentrated on achieving several spectacular firsts, with high propaganda value, in the field of space investigation, whereas the United United States had accumulated more scientific information from their space probes. Summarizing the current situation, Dr. Millman states that of 73 successful launchings since Sputnik I, 15 had been achieved by the Russians, and 58 by the United States.

Dr. Millman commented that there was no question of the authenticity of Russian achievements, since the same standard of integrity in reporting scientific observations and achievements applied to the Soviet research staffs as to those of the Western world.

Looking into the future, Dr. Millman showed some details of space vehicles now in development, concluding his address with a display of some imaginative pictures of future manned space vehicles to the Moon and Mars. These vehicles were envisaged by Wernher von Braun, formerly responsible for the technical direction of the German rocket establishment at Peenemunde, and now occupying a similar position in the artificial satellite program of the National Aeronautics and Space Administration of the United States.

Belleville

A. F. G. Tooth, M.E.I.C.
Correspondent

R. A. Preston, professor of history at the Royal Military College, Kingston, was guest speaker at the Branch dinner meeting Nov. 13, at the Queensway Hotel, Trenton. Professor Preston chose as his subject, 'Current Affairs'. In discussing the resumption of nuclear testing by the Soviet Union and the United States, Prof. Preston said it is evident that a position of nuclear stalemate has been reached with each side believing it can retaliate with equivalent weapons in event of attack. He said this may be the deterrent to the development of a nuclear war. Prof. Preston then explained the formation of the United Nations Organization with particular reference to the duties of the Secretary General, and his responsibilities to the Security Council and the General Assembly.

Border Cities

V. Corin, A.M.E.I.C.
Correspondent

Some 170 members, wives and guests attended the annual Branch dinner dance held Oct. 20 at the Essex Golf and Country Club. President B. G. Ballard and Mrs. Ballard were guests of honor. Dr. Ballard spoke briefly about 'Learned Societies in Research'. C. G. P. Armstrong thanked the speaker. A toast to the women was proposed by R. D. Gilbert and a gold pin was presented to J. M. Reid, immediate past Chairman of the Branch. A social evening followed.

Brockville

A. N. Campbell, M.E.I.C.
Correspondent

Chairman J. R. Eastwood presided at the Branch's November 24 meeting. Guest speaker J. J. Gagnon, Manager, Industrial Relations Division, Aluminum Company of Canada Limited, Montreal, discussed "Personnel Administration — What? How? Why?"

Mr. Gagnon began by asking four questions: "What is personnel administration? What are the essential elements of sound personnel administration? Why do we need personnel administration? Who is responsible for personnel administration?" After dwelling on the questions in an interesting and a provocative way, Mr. Gagnon discussed personnel administration in reference to collective bargaining, the role of the specialist in the field, and dealing with unions. He ended his talk with a final question: "Do human relations have a future?"

The extremely interesting session was well received. Mr. Gagnon was introduced by F. F. Walsh and thanked by W. F. Currie.

G. M. Woods reported progress on the Science Fairs project to be held in February.

(Continued on page 88)

Calgary

R. L. Turner, A.M.E.I.C.
Correspondent

At the Branch meeting of Nov. 1, C. K. Hurst, Harbours & Rivers Engineering Branch, Department of Public Works, Ottawa, was guest speaker. Mr. Hurst's speech was entitled, 'International River Development'.

Some 270 persons attended the Branch barbecue held Sept. 9 at Colpitt Ranch. The main course consisted of roast beef, spare ribs, chicken and fish. A four-piece band provided square dance music, and for the sports minded guests a television set was tuned to the Calgary Stampeder-Edmonton Eskimo football game.

This year the Branch is sponsoring a student from East Africa in the faculty of engineering at the University of Alberta. When the new executive took office in April it was agreed that the membership be asked to pledge a sufficient amount of funds to support a student. Enough money was obtained to sponsor two students. Only one student, however, was able to participate this year and the money which is held in a trust fund for this sole purpose will be available for a second student one year from now.

Cape Breton

Lloyd Boutilier, M.E.I.C.
Correspondent

Lt.-Col. J. E. Thorpe, Zone Co-ordinator, Civil Defence, Cape Breton Area, was guest speaker at the Branch meeting of Oct. 25. Lt.-Col. Thorpe chose as his subject, 'Nuclear Fallout, And How to Protect Ourselves From It'. Following a film, 'The H-Bomb', he compared the destructive characteristics of different strength H-bombs and described the various areas of destruction. The speaker said seven per cent of the population should be trained in one way or another in case of an emergency. A second film, 'Fallout', was then shown. Chairman Rod Bradley introduced and thanked the speaker.

Central B.C.

A. F. Joplin, M.E.I.C.
Correspondent

Brian S. Harvey, Whonnop Hirtle & Associates, Kelowna, was elected president of the Branch at the annual election of officers Nov. 17. Other appointments include M. Elston, regional engineer, Dept. of Highways, Kamloops, as Vice-Chairman and Vice-President; R. K. Coates, Trans-Canada Highways, Revelstoke, R. G. Harris, Water Rights Branch, Kelowna, E. Cameron, Penticton, as members of the Branch Council. These men, with A. L. Freebairne, also serve as directors for the A.P.E.B.C. R. J. Talbot, Kamloops, will continue as Secretary-Treasurer of the Branch, and J. D. Robertson, also of Kamloops, was re-elected Secretary of the Association Branch.

J. W. Nelson, retiring Chairman, submitted the annual report of the Branch's activities for the year together with a suggested program of meetings for the coming year. While membership during the year showed a decrease of five members, there was an increase of 29 students.

The program for 1962 includes a meeting on Jan. 19 at Vernon and meetings at Penticton in March; Kelowna in May; Roger's Pass and Trans-Canada Highway East of Revelstoke, June 1.

Cornwall

J. M. Ferguson, M.E.I.C.
Chairman

Paul Walters, district engineer of the Harbour Branch of the Department of Public Works, Ottawa, organized a presentation of the design and construction of the harbor in Cornwall for the Nov. 16 meeting of the Branch. Twenty members attended.

Three of Mr. Walters' associates spoke on different aspects of the harbor. L. T. Vaughan of Canadian-British Engineering outlined the preliminary survey and the design of the harbor. Lindsay Morris, resident engineer at the project, discussed the actual construction of the dock at the harbor and M. W. Paul spoke about the construction of docks similar to the one being built in Cornwall. All the talks were accompanied by drawings and colored slides.

The speakers were introduced by Charlie Adams and thanked by Lorne Raham.

Edmonton

W. Rutherford, M.E.I.C.
Correspondent

The Branch met on Wednesday, November 22nd, at 5:30 p.m. in the Seven Seas Restaurant. Mr. Adam Sandilands was Chairman. The speaker of the evening was G. C. Hamilton, a Commissioner of the City of Edmonton, who spoke on the "Current Central Area Plan" in downtown Edmonton. Mr. Hamilton pointed out that there was a need for a plan of orderly city development in Edmonton, which has been one of the fastest growing cities in Canada. It was not without a considerable amount of thought that the city had entered into consideration of a development plan. As a result of many technical reports they have considered what the estimated population increase would be in the future and it has been estimated that this would be approximately one million at the turn of this century. The traffic problem in Edmonton, with the present level of population, is already severe and with increasing population in the urban areas, this traffic problem would become unmanageable, so that any development plan would include an appreciation of parking, transportation and any other problems associated with traffic and in particular the traffic in the central area of Edmonton could be most acute. The city, taking account of many reports by consultants and technical experts, presently considers that the area bounded by the C.N.R. tracks on the North, 97th street on the East, 100th Avenue and the River Bank on the South and 109th Street on the West should be developed as the central area of the city. This area is considered to be of sufficient size to serve the needs of the City, bearing in mind the population increase in the forseeable future. Mr. Hamilton pointed out that there was a general trend for new development in the City of Edmonton to move westward and though this is to be expected, it is still necessary to be able to further develop the areas which are presently occupied by the older property.

The property on the eastern side of the projected central area amounting to about 60 acres is older property which in the majority of cases has already outlived its useful life and as there has been no private development in that area for many years, nor has the city been able to create any interest in that area, even with the building of a new City Hall in the immediate vicinity, the City Planning and Development sections have been investigating the possibilities of what stimulation can be generated to improve the situation. The city have recently been approached by a development trust, Webb and Knapp (Canada) Ltd., who suggested that they would consider redeveloping this Eastern area in return for rights of participation in the developments and the city are actively considering this proposal. The details of the proposal by this company were summarized as follows:

(a) The Company to spend $100,000 to prepare a planned development proposal during a period of four months, and the city would not approve any other development proposals in this 60 acres during this period.

(b) The city would consider this proposal, retaining however, their right to approve or disapprove of the plan prepared by Webb and Knapp.

(c) In the event of approval by the city of the development trust proposals, then that company would acquire the following rights from the city:

1. Acquisition of 50% of the 60 acres involved in the planning proposal.
2. The right to pay for the aquisition of this land at a fair market price as assessed by at least two independent appraisals.
3. The city would retain their right to determine which of the land within this 60 acres should be made available for the development trust.

After a lively question and answer period ably dealt with by Mr. Hamilton, he was thanked by T. H. Newton, on behalf of the Membership, for this very fine talk on this very topical subject.

The meeting was adjourned at 8:05 p.m.

Estevan

O. P. Lesiuk, M.E.I.C.
Correspondent

The Branch held a meeting Oct. 10 at which O. P. Lesiuk, Petroleum Development Officer II, Saskatchewan Department of Mineral Resources, was guest speaker. Mr. Lesiuk in his speech entitled 'Civil Defence—Radiation and Fallout', dealt with the basic concepts of radiation and fallout and the necessary precautions to be dealt with in fallout. He described the local civil defence and

mentioned the need for a fuller knowledge of nuclear radiation and its effects. He spoke of the value of various types of shelters and the ways of improvising under existing conditions. The speaker was thanked by Glen Hedges.

A Branch dinner dance scheduled for Oct. 27 at the Elks Hall was postponed until Nov. 3 due to the sudden death of Duanne MacKenzie, a charter member of the Estevan Section of the A.P.E.S.

Newfoundland

Anthony Nemec, M.E.I.C.
Correspondent

Barry Saper, manager of the Satellite Tracking Station, was guest speaker at a joint meeting of the Branch and the Military Engineers' Association Nov. 1. The meeting was held at Buckmaster's Field Officers' Mess. Mr. Saper outlined the function of the station which is operated in Canada through a joint agreement with the National Research Council, and the NASA in Washington. The speaker outlined the coordinated tracking operation in conjunction with other stations which are located in South America, Alaska, Australia and Europe. He reviewed the history of all satellites that have achieved orbit and pointed out the great difference in the U.S.A. program, which is basically for research, and that of the U.S.S.R. program, which is based on much heavier, more spectacular but short-lived orbits. These, he said, give very limited scientific information in comparison with some U.S. satellites which will be in orbit for 200 years or more.

Films were shown which depicted the successful flight of Alan Sheppard; the 100 ft. diameter communication balloon which is still in orbit and can be seen at times passing over Canada; the development of the largest known missile which has eight separate rocket engines in the first stage alone.

Over 100 persons attended the meeting. Afterwards, a lunch was served.

Nipissing and Upper Ottawa

J. S. Cooper, M.E.I.C.
Correspondent

The monthly dinner meeting of the Branch was held Nov. 15 at the White Oaks Inn, Temiskaming. R. A. Booy, Chairman presided and 26 members and guests were present.

The guest speaker, C. M. Waters, was introduced by N. Burke. Mr. Waters, who graduated as a chemical engineer from La Crosse State College, Wis., is Boston District Manager of the Dicalite Division of the Great Lakes Carbon Corporation. His topic was "Filtration".

The speaker explained that in a filtration process where suspended solids are to be removed from a liquid it is necessary to use a filter aid in order to prevent the particles from matting on the screen and restricting the flow. The filter aid is mixed with the liquid to be filtered and maintains porosity on the filter screen.

(Continued on page 95)

Library Notes

Prepared by the Library, The Engineering Institute of Canada

Book notes marked by an asterisk have been provided through the courtesy of The Engineering Societies Library in New York.

*CERAMICS.

Following a preliminary review of the history, raw materials, and basic chemistry of ceramics, the application of ceramic materials in industry is discussed. Specifically the use of ceramics in electronics, dentistry, high temperature refractories, low temperature enamels, abrasives, and cermets is covered. Particular attention is given to recent developments. (P. W. Lee. New York, Reinhold, 1961. 210 p., $5.95.)

MAGNETIC CONTROL OF INDUSTRIAL MOTORS.

PART 1 A-C control devices and assemblies
PART 2 A-C motor controllers
PART 3 A-C motor controllers

Industrial type a-c and d-c motors are carefully analysed in conjunction with their associated controllers. Motor performance data for the a-c squirrel-cage, wound-rotor, and synchronous motors are presented, as well as data on d-c series and shunt motors. Principal circuits, selection of controller sizes and components, economic factors affecting controller selection, motor protection, and existing safety codes and standards are given complete coverage. (G. W. Heumann. New York, Wiley, 1961. 3 vols., $27.00.)

*ITERATIVE ARRAYS OF LOGICAL CIRCUITS.

The properties of the various classes of iterative systems and the various tests that are available for answering simple questions about them are developed in a logical fashion. It is shown that there are no general procedures for answering most of the basic questions about iterative networks. The techniques that are presently used for designing and simplifying sequential switching circuits are then extended to various types of iterative networks. (F. C. Hennie. New York, Wiley, 1961. 242p., $4.95.)

ELEMENTARY CHEMICAL THERMODYNAMICS.

Intended for students taking a first course, this study of thermodynamic functions emphasizes their meaning and use in chemistry, and shows the applications of the first two laws of thermodynamics. (G. Hargreaves. Toronto, Butterworth, 1961. 120p., $2.00.)

DICTIONNAIRE DE METALLURGIE.

A dictionary of terms used in metallurgy in general, and foundry work in particular, this volume contains lengthy definitions and descriptions of over 700 terms and processes. Many diagrams and tables are also included. The English equivalent of each terms is given, and there is also an index of the English terms included. The authors of this most useful dictionary are, respectively, a chief metallurgist and the operator of a foundry. (O. Bader and M. Theret. Paris, Eyrolles, 1961. 701p., 70 NF.)

STAHLBETON-RIPPENDECKEN.

The third in a series of worked examples of the design of reinforced concrete. The five examples in this book are concerned with ribbed ceilings. The method of design is given, and calculations for the example are shown. (Adolf Kleinlogel. Berlin, Ernst, 1960. 52p., 14 DM.)

INDUSTRIAL WATER TREATMENT PRACTICE.

Prepared originally by the company for circulation within Imperial Chemical Industries, this text has been brought up-to-date and modified for publication. It is concerned with water treatment for use in steam generation and as cooling water, but much of the information is applicable for other industrial uses. The topics covered include: impurities in water and their effects; precipitation processes in water treatment; evaporation; boiler systems, scales and deposits and corrosion; boiler feed-water treatment; treatment for stationary, locomotive and marine boilers; cooling-water treatment; control of organic growths; clarification and colour removal. A twenty-page bibliography is included. (Ed. by P. Hamer and others. Toronto, Butterworths, 1961. 514p., $16.50.)

THE ENGINEERING INSTITUTE LIBRARY

The publications mentioned in these notes are now available in the Library, and may be borrowed by members of the Institute. Two items may be borrowed at one time for a period of two weeks, excluding time in transit.

Library hours are: Monday to Friday: 9 a.m. to 5 p.m.; Saturdays: 9 a.m. to 12 noon. All requests and enquiries should be addressed to the Librarian at 2050 Mansfield Street, Montreal.

A SOCIAL HISTORY OF ENGINEERING.

This is a history of technological developments, particularly in Britain, showing how they have affected and been affected by social life, and indicating the origins of some innovations and institutions.

The author commences his history with the contributions of the Greeks and Romans, and takes it to the present, discussing in a final chapter some of the problems faced by society, problems for which engineers must help find the solution. Throughout the book, the work and contributions of individuals have been emphasized, as well as the important part played in the past by the amateur man of science. This is an absorbing history, and a lengthy bibliography is included for those who wish to pursue the subject further. (W. H. G. Armytage. Toronto, British Book Service, 1961. 378p., $9.50.)

AUDIO FREQUENCY ENGINEERING.

Intended for those with a knowledge of electricity, who wish to specialize in the field of electroacoustics, this text assumes a knowledge of electrical measurements, thermionic and transistor amplifiers and four-terminal network theory. The emphasis throughout is on fundamental theory, and the topics covered include the mathematics of sound, the propagation of acoustic waves, the sources of sound, and the mechanisms of hearing and speech. The remaining chapters discuss architectural acoustics, microphones, receivers, magnetic and disc recording, and film recording and reproduction. (E. H. Jones. Toronto, Clarke, Irwin, 1961. 245p., $7.75.)

WATER POWER DEVELOPMENTS VOL 2 HIGH-HEAD POWER PLANTS.

Although based on the original Hungarian edition, this English edition has been considerably enlarged, to include more information on high-head power plants, which are rarely found in Hungary, surge tanks, pumped storage and underground power stations.

The first section of the book covers high-head power plants, under the headings: characteristic features and main types; free-flow conduits; pressure tunnels, including surge tanks; penstocks and penstock equipment; power house design; developments with concentrated fall; hydraulic machinery and electrical equipment.

The second section of the book covers midget power plants, both those with water wheels and those with turbines. The last section considers pumped storage developments, their general arrangement, mechanical equipment and operating conditions.

The book includes many diagrams and illustrations of actual installations, both in Europe and on this continent. There is a useful bibliography of thirteen pages.

The first volume, published in 1957, dealt with low-head power plants, and a third volume will cover river barrages, including high dams, steel structures and mechanical equipment and operation and maintenance, and also the economic aspects of hydro power. This will be a most valuable series. (Emil Mosonyi. Budapest, Hungarian Academy of Sciences, Toronto, Pannonia, 1960. 1139p., $23.00.)

MARINAS: RECOMMENDATIONS FOR DESIGN, CONSTRUCTION AND MAINTENANCE, 2nd ed.

The boom in boating in recent years has greatly increased the need for the services provided by marinas. This volume covers virtually all aspects of the construction and operation of marinas, including site investigation, design, timber piles, the use of concrete, steel and other materials, bulkhead walls, dredging, pile driving, floating equipment, boat handling equipment, fire prevention, water and sewage, fuel supply, ground development, construction costs, maintenance and operational costs. (C. A. Chaney. New York, National Assoc. of Engine and Boat Mfrs., 1961. 247p., $7.50.)

*LARGE PLASTIC DEFORMATION OF METALS AT HIGH PRESSURES.

A translation of a Russian work, this monograph surveys and analizes the results of research on plastic deformation of metals at high pressures. It discusses the influence of hydrostatic pressure on plasticity of metals, the conditions of metal flow from the matrix eye during extrusion by a high-pressure fluid, the mechanical properties of metals extruded by a high pressure fluid, and the technological possibilities of extruding articles from metals by a high-pressure fluid. (B. I. Beresnev and others. West Newton, Friedman, 1960. 36p. mimeog., $6.00. no. B-181.)

*INTRODUCTION TO ENGINEERING MECHANICS.

The fundamentals of mechanics are emphasized in this work which differs from similar texts in its selection and sequence of topics. The author has divided the subject on the basis of particles, rigid bodies, and deformable bodies, as opposed to the traditional separation of statics and dynamics that makes little mention of deformable bodies. In addition a general vector algebra is developed and vector notation is used freely for those parts of the theory in which such notation seems advantageous. (J. V. Huddleston. Reading, Addison-Wesley, 1961. 493p., $9.75.)

BIOGRAPHY OF PHYSICS.

This history combines the facts and theories of physics with the biographies of the men responsible for their discovery. Each of the eight chapters centers about one or two great figures, with the other physicists of that era and their contributions forming a background. There are discussions of the work of Galileo, Newton, Faraday, Einstein, Bohr, Rutherford, Heisenberg, and personal glimpses of them, augmented in the case of twentieth century figures by the author's personal recollections. Included are many line drawings done by the author, who is well known for his other histories of science. (George Gamow. Toronto, Musson, 1961. 338p., $5.95.)

*OPERATIONAL ELECTRICITY.

An integrated study of a-c and d-c circuits and machines, in which direct current is treated as the special case of alternating current at a frequency of zero cycles per second. The electric circuit is presented for the general case, and, when applicable, the discussions include the zero-cycle system. Wherever possible, the author has injected applicable operating techniques in addition to treatments of the parallel operation of generators, the selection and application of motors and controls, magnetic controllers and regulators. (C. I. Hubert. New York, Wiley, 1961. 530p., $8.50.)

*BRITISH MINIATURE ELECTRONIC COMPONENTS AND ASSEMBLIES DATA ANNUAL, 1961-62.

This first volume in an annual series contains data in concise form on a wide variety of miniature components. In addition to technical data on each miniature component, information is given on the effects of potting resins, nuclear radiation, temperature overload, vibration, etc. Components included range in size up to about one cubic inch. Only those components manufactured or assembled in the United Kingdom are included. (G. W. A. Dummer and J. M. Robertson, eds. New York, Pergamon, 1961. 479p., $15.00.)

(Continued on page 98)

Employment Service

THE ENGINEERING INSTITUTE OF CANADA

This service is operated for the benefit of members of the Engineering Institute of Canada and for organizations employing engineers.

SITUATIONS WANTED

Advertisements are inserted free of charge for members of all classes. Maximum length is 60 words, and repeat insertions must be separately requested in writing for each desired appearance.

SITUATIONS VACANT

Rate: Six dollars per column-half-inch per insertion.
Replies to advertisements should be addressed to the file number, Employment Service, 2050 Mansfield Street, Montreal. Interviews with the Employment Service may be arranged by calling VI 2-8121 at the above address.

SITUATIONS WANTED

ELECTRICAL ENGINEER, M.E.I.C., Age 35, graduate 1950. Sound knowledge of general electrical controls, heavy electrical machinery, plant power distribution, pneumatic and electronic process instrumentation, plant services equipment, administration of project engineering, construction and maintenance. Desires responsible senior position requiring a matured man with diversified experience. Will consider any location. File No. 5962-W.

MECHANICAL ENGINEER 1954, M.E.I.C., desires responsible position in Montreal or its vicinity. Experience includes over 7 years in the Engineering and Maintenance Departments of Pulp & Paper Mill. File No. 6394-W.

Graduated University of Toronto in Civil Eng. 1960. Research Assistant at University of Illinois from September 1960 to February 1962, working on Prestressed Concrete project. Receiving M.S. in Structural Engineering February 1962. Married, Age 24 yrs. One child. Willing to work in any part of Canada, preferably in the consulting field. File No. 6397-W.

MECHANICAL ENGINEER, A.M.I. MECH.E; M.E.I.C. Age 33, Married. Nine years construction experience in Britain and Far East as Project Engineer and Supervisor, two years in Canada as Mechanical Engineer on large contract. Specialized in Mechanical Structures, etc., seeks permanent position as Plant Engineer or similar in Eastern Canada or Central Canada. Would also be interested in consulting. File No. 6428-W.

CHEMICAL ENGINEER, M.E.I.C., P.Eng., (Que.), B.Eng. McGill 1950, age 41, two children, 11 years experience in the gas industry including quality control, maintenance, manufacturing and more recently natural gas measurement and dispatching, seeks interesting and challenging position in the gas measurement field. Available 1 month notice. Located Central Canada. File No. 6432-W.

CIVIL ENGINEER, A.M.E.I.C., B.E. Sask. 1961, Age 24, Married. Presently employed in the municipal field with a consulting firm. Summer experience in concrete construction. Would like a position in structural design and sales. Presently located in Prairie province, but available on one month's notice in Canada or abroad. File No. 6433-W.

SENIOR ENGINEER, M.E.I.C., P.Eng. (Quebec), B.A.Sc., University of Toronto 1922, has varied engineering experience; industrial instruction, teaching experience; surveying, designer-draughtsman, tool engineering, structural steel, reinforced concrete experience; accomplished recent post-graduate studies:—Physics, Mathematics, Ethics, Philosophy of Education, Education, Electricity, Automotives. Interested in inspection, research, Industrial Psychology, safety engineering, College or University staff position. Hold C.W.B. diploma, teaching certificate. File No. 6439-W.

CIVIL ENGINEER, A.M.E.I.C., P.Eng. in Quebec, 23, graduate of McGill '61, single, some experience in railway and pipeline construction and supervision. Would prefer position in construction field, but would accept any favourable position. File No. 6440-W.

PROFESSIONAL ENGINEER, Que. B.Sc.A. '57, Business Administration A.H.I. (N.Y.), fully bilingual, age 29. Undergraduate experience in forestry and mining. Graduate experience all with a multi-plants chemical, extractive and physical metallurgical concern where one year was spent in process development and four years as plant maintenance engineer including successive one year stages in different plants. Seek responsible position with industrial or consulting firm. Present salary $600. File No. 6441-W.

SENIOR EXECUTIVE POSITION under coherent and far-sighted management, by graduate British engineer, age 51, M.E.I.C., P.Eng., 30 years' experience in England, Latin America and Canada, in engineering sales of heavy electrical equipment of all kinds and all types of thermal prime-mover; available January 1, 1962. File No. 6442-W.

TRAFFIC AND HIGHWAY ENGINEER, A.M.E.I.C., B.Sc. (Western '60—Civil), completing M.S. (Queen's) in spring of 1962. Age 24, married. Desires position which will offer wide experience in the highway, field. Any location will be considered. Available for employment July 1962. Full resume on request. File No. 6443-W.

MECHANICAL ENGINEER, M.E.I.C., P.Eng., Age 41, Graduate 1950, U. of S. Married with family. 10 years' experience in Manufacturing Engineering and Assembly Operations the past six years in the Automotive Industry. Desires a responsible challenging position. Location preferred Southern Ontario, but will relocate. File No. 6444-W.

Production Control — Mechanical Engineer, A.M.E.I.C., P.Eng., with Master of Business Administration majoring in production and marketing. Age 28, with four years' experience in production, design and industrial engineering. Desires position with opportunities leading to general management responsibilities in a small to medium sized company. References available on request. File No. 6445-W.

ELECTRICAL ENGINEER, B.Sc. (E.E.) 1950, P.Eng., M.E.I.C., two years' post-graduate training in electrical industry, married, age 33, presently employed as a Marketing Supervisor, desires managerial post. Has fundamental experience in Engineering, Manufacturing, Marketing, Field Sales and Service. Most depth in product promotion, catalogues, estimating and pricing, market forecasts, statistics, departmental budgets and cost analysis. File No. 6446-W.

SENIOR MANAGEMENT ENGINEER, P.Eng. (Ont.) M.E.I.C.; A.I.I.E., age 50, 30 years' diversified experience 10 years in Canada, wants tougher assignment, where results, rather than birth data and conformity count. Analytical mind, innovator, drive; successful director etc. Optimist Club; A-1 health; min. salary $12,000. File No. 6447-W.

SITUATIONS VACANT

CHEMICAL

CHEMICAL ENGINEER — Five years' experience in the development of industrial processes. Sound background in physical chemistry and chemical engineering principles. Ability and training is more important than specific experience. Opening is for process development work with progressive consulting group located in Toronto. File No. 7391-V.

CIVIL

PLANT ENGINEER is required by a progressive, expanding prestressed concrete manufacturer, located in Western Ontario. A degree in Civil or Structural engineering is essential and some field experience in reinforced and/or prestressed concrete is desirable. File 7388-V.

MECHANICAL

MECHANICAL ENGINEER, Heating, ventilating and air conditioning work for a consulting engineer. Minimum two years of design experience with outstanding technical ability and partnership potentiality. Location Winnipeg. File No. 7387-V.

MECHANICAL ENGINEER (Bilingual) ventilation, refrigeration experience. To service as product application specialist in covering consulting engineers (Montreal Area) for Sturtevant Division of this Company. Progressive Salary plan. Excellent medical and pension plan. All replies held in strict confidence. Applications in writing only to Canadian Westinghouse Co., Ltd., Attention E. Dineen, 415 Craig St. West, Montreal, Que. File No. 7397-V.

(Continued from page 91)

Diatomaceous earth was considered as a filter aid. It is found in large deposits on dried up lake beds or salt water basins and is the accumulation of skeletons of microscopic aquatic plant life known as diatoms. Diatoms extract silica from water and form a minute skeleton of inert material.

Mined by the open pit process, and deposits of diatomaceous earth may be 1,500 ft. deep. Slides were used to illustrate the mining and processing of this material.

A filtration process using diatomaceous earth as a filter aid was installed at the Kipawa Mill of the Canadian International Paper Company where photographic paper is made. For this reason all traces of radioactive particles from the water must be removed or the emulsion will be full of black specks. Traces of radioactive metals and sand dust resulting from nuclear blasts in the air and on the ground have been found in the water, which when filtered loses the potentially damaging materials.

Mr. Waters was thanked by J. W. Millar, M.E.I.C., of North Bay.

Members from Temiskaming, Que., and Sturgeon Falls, Ont., were present at the monthly dinner meeting of the Branch held at the Golden Dragon Restaurant in North Bay. Chairman R. A. Booy presided.

The guest speaker, H. R. Neifert, Chief Engineer, Physical Laboratories, Timkin Roller Bearing Co., Canton, Ohio, was introduced by Mr. Cooper. Mr. Neifert's topic was Improving Fatigue Resistance with Residual Stresses. He explained, with the assistance of slides, the different methods of increasing the fatigue resistance of metal in axles and shafting to improve service life which is so important in ensuring trouble-free operation with a minimum of maintenance.

These methods are by geometrical change of shape, mechanical prestressing such as surface rolling and thermal treatment which includes quenching from temperatures below the critical level. Slide graphs clearly illustrated the pronounced increase in fatigue resistance possible by the above methods.

The speaker was preceded by a sound film depicting roller bearing manufacturing at his plant. A lively discussion period followed Mr. Neifert's talk, after which he was thanked by R. T. Williams.

Oakville

A. A. Swinnerton, M.E.I.C.

Professor B. Etkin of the University of Toronto's Institute of Aerophysics was guest speaker at the Branch's December 6 meeting. Prof. Etkin, dealing with the entry of manned vehicles into planetary atmosphere, said the three main problems are the deceleration of the vehicle, dissipation of heat generated by friction with the atmosphere, and protection of personnel.

The mathematical analysis of the physical quantities involved was demonstrated. Prof. Etkin indicated that a certain amount of navigation would be required of the personnel to reach the corridor of approach. Also discussed was the use of satellites for radio transmission and for assistance in weather prediction. Prof. Etkin illustrated his talk with slides and diagrams.

During the business meeting nominations were held for the Executive Committee and auditor for the Treasurer's report was appointed.

Peterborough

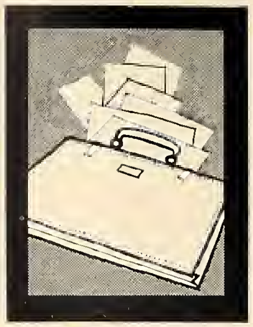
R. C. Johnston, JR.E.I.C.
Correspondent

Dr. Vincent Bladen, Dean of Arts and Sciences at the University of Toronto, addressed the November 28 meeting of the branch. Dr. Bladen discussed some aspects of the economics of higher education.

The economic wealth of a country is directly related to the level of education attained by its people, and as a society increases in complexity, it becomes more dependent on the trained specialists. The benefits from a higher educational system would extend to all levels of a society. Education can and should be considered as a durable consumer good, with the supply falling behind the available market. Since education develops a fuller man and a richer life, it is sought by the individual from a

(Continued on page 97)

Business and Industrial Briefs



Appointments and Transfers

R. J. Barrett, President of Dominion Engineering Works Ltd., has announced the appointment of **K. S. Barclay** as secretary-treasurer. Mr. Barclay previously held the offices of secretary and assistant treasurer.

Dow Chemical of Canada, Ltd. recently announced the appointment of **J. M. Hacking** to assistant vice president. Mr. Hacking will be responsible for the Company's public relations, and will also continue his present liaison work with the various branches of the Federal and Provincial Governments. He is a graduate in Chemical Engineering from the University of Toronto and has been with Dow Chemical since the formation of the Canadian Company in 1942.

E. L. Hartley, president of Dominion Structural Steel Ltd., recently announced the appointment of **G. J. Jackson** as District Manager of the Company's Toronto operations. Mr. Jackson was formerly Sales Manager of the Toronto Plant.

Montreal Locomotive Works, Ltd., recently announced the appointment of **John J. Norris** as vice-president. In addition to his new duties Mr. Norris will continue to serve as comptroller and treasurer.

The appointment of **I. B. Blanchard** as chief engineer has been announced by Du Pont of Canada Ltd. **A. L. Barry**, formerly production manager in the films department, succeeds Mr. Blanchard as production manager in the textile fibres department.

F. Perry Wilson has been appointed vice-president of Union Carbide International Company in New York. Mr. Wilson has been executive vice-president of Union Carbide Canada Ltd. since April, 1959.

Sifto Salt Ltd. has announced the appointment of **N. F. Kalin** as Maritime District sales manager replacing G. W. Kerman who has been transferred to Central District as sales manager. Mr. Kalin is a graduate in Chemical Engineering from the University of Saskatchewan. He joined Sifto Salt 13 years ago.

Frank J. Dobson, construction manager of Ontario Hydro's $250 million Lakeview thermal-electric development, has been named chief executive of the new Volta River Power Authority by Ghana president Kwame Nkrumah. Mr. Dobson will be on loan from Hydro until the project is finished probably in four or five years.

Dominion Bridge Company Ltd. has announced the appointment of **Lazarus Phillips** to the Board of Directors.

Developments

Information contained in this section has been obtained from press releases. Mention of products and services does not imply endorsement by the Institute.

ASBESTOS-CEMENT pressure and sewer pipe, manufactured by Atlas Asbestos Co. in Montreal, is now available in 18-inch diameter in addition to four inch (in the case of sewer pipe, six inch) up to 16-inch dimensions. The 18-inch Turnall pressure pipe is supplied in the 100-150-200 classes, while the same diameter of sewer pipe is available in 2400-3300-4000 and 5000 classes.

A NEW STATIONARY air compressor in the 350-400 hp. range has been introduced by Atlas Copco Canada Ltd. The electrically driven, water cooled ER8, for service in larger industries and mines, is more compact, lighter and uses less power than other compressors of the same class. These features are achieved by a short-stroke design which allows higher rotational speeds while maintaining low piston speeds.

CANADIAN ALLIS-CHALMERS LTD. has announced the expansion of its Hydrocone crusher line with the addition of a 45-inch unit. The new medium size (33,300 lb. 5 ft. 8 in. high) unit is ideally suited for portable crushing plant service as well as permanent installations.

AN ORDER for 16 mechanical-drive turbines and a large 3350 hp. outdoor synchronous motor for a refinery near Adelaide, Australia has been received by Canadian Westinghouse Co. The order is the third received by the Hamilton Company in recent months for equipment for Australian refineries.

UNION CARBIDE Canada Ltd., announced recently that 60 Canadian University students will share in the Company's $150,000 scholarship program this year. Each scholarship is valued at $2,500, with the student receiving $700 for the first year, and $600 a year for the following three years of his academic studies. Nineteen universities participate in the program. In addition to the 60 scholarships, the Company also makes available four $2,000-a-year post-graduate research fellowships, two at the University of Toronto, and two at McGill University in Montreal.

A HERMETIC CENTRIFUGAL UNIT called the 60 series Tonrac has been introduced by American-Standard Products (Canada) Ltd. The result of a five-year development program, this machine features reductions in size and weight over conventional equipment and is now available in eight size increments from 50 to 110 tons nominal refrigeration capacity. Intended for use as the heart

(Continued on page 104)

(Continued from page 95)

subjective viewpoint. If able to qualify, a man should avail himself to this richer life. In this case, what is good for the individual, is also good for the society. Dr. Bladen pointed out the inadequate development of new facilities at Canadian universities, predicting that without major support by federal and provincial governments, facilities and teachers would be unable to cope with the flood of students by 1970. Also mentioned was the lack of support for deserving students, not only at the university level, but also in high schools.

The Branch's Engineering Ball will be held February 16. On March 28-29, the Branch is holding a major exhibit on atomic energy work in Canada with the cooperation of the Atomic Energy of Canada Limited, and Canadian General Electric. Working models of Canadian atomic reactors and nuclear power plants will be displayed, as well as displays of components and equipment. Short talks and films will also be featured. The sessions will be open to the public, with scheduled attendance by schoolteachers and students. At an Engineers' dinner March 28, J. L. Gray, President A.E.C.L. will be guest speaker. Guests from other E.I.C. Branches will be most welcome.

Sarnia

Joseph P. Zanyk, A.M.E.I.C.
Correspondent

G. B. MacCoy, manager of engineering and construction, Dow Chemical of Canada Ltd., was the featured speaker at the Oct. 17 meeting. In his address, entitled "The Dow Steam Generating Plant", the speaker outlined the designing and construction of the plant.

When first put into operation in September, 1960, the Plant consisted of two Riley stoker "turbo" boilers each of 300,000 lb./hr. capacity and a water treatment plant which is one of the largest in Canada. The capacity of this plant is based on 100% make up to the three boilers with no condensate return. The third boiler is identical to the other two. Slides were used by the speaker to illustrate his talk.

H. Page, M.E.I.C., Branch Chairman introduced Mr. MacCoy who was thanked by P. Cochrane.

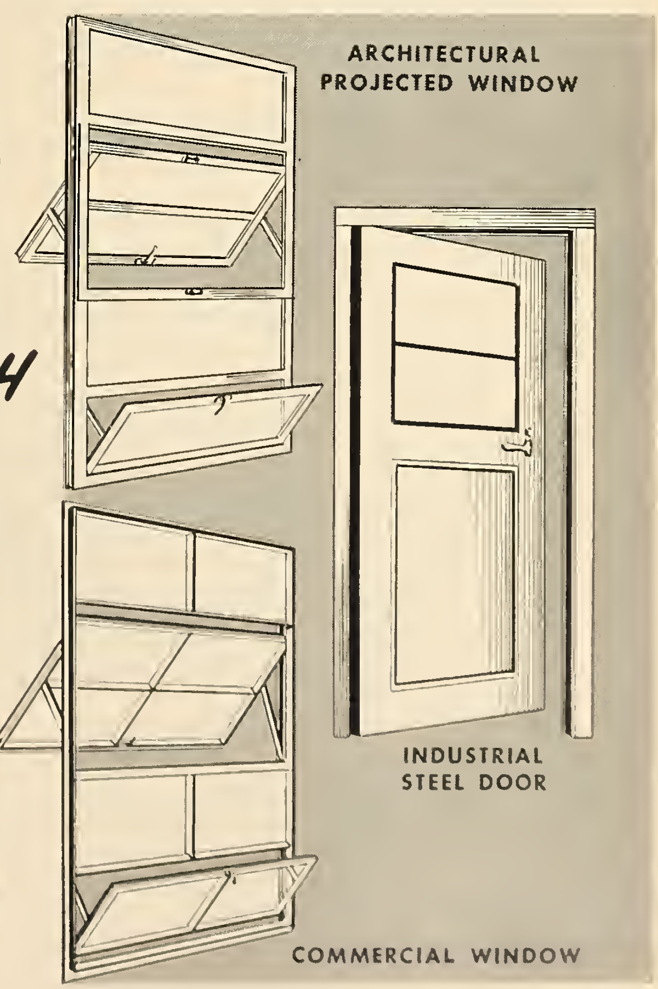
Winnipeg

P. A. Brett, M.E.I.C.
Correspondent

A Branch dinner meeting was held at the Pembina Hotel Oct. 5. After dinner, three members associated with the City of Winnipeg Hydro Electric System discussed the City's new Central Control Station. W. E. Tabbenor gave the reasons for the site location and gave a detailed description of the supervisory control system. W. L. Bunting described the physical aspects of the building including lighting, heating and construction materials. The background and history of the Winnipeg Hydro — Winnipeg Electric relationship which contributed towards the decision to build a central control station were given by M. Spigleman. After the discussion, the members made a tour of the station.

The **CHALK RIVER BRANCH** has awarded its annual prize to Brian Mitchell, Deep River. This award is made to the Deep River High School Grade XIII graduate with the highest standing of those entering a university engineering course. The prize, 'Eshbach', (engineering handbook), was presented in absentia during the school commencement exercises of Nov. 17. The **EASTERN TOWNSHIPS BRANCH** was host to the President, Dr. B. G. Ballard and Mrs. Ballard, Oct. 27, at a dinner dance in Sherbrooke which was attended by some 80 persons. The **MOOSE JAW BRANCH** held a meeting Oct. 25 at which films covering the blasting of Ripple Rock and winter construction were shown. A business meeting and social evening followed. Dr. A. Casagrande, professor of soils mechanics and consulting engineer, Harvard University, was guest speaker at the **SASKATOON BRANCH** meeting of Oct. 18. Prof. Casagrande's speech entitled 'Foundations on Soft Soils', was accompanied by slides. He described some of his experiences on projects in which soft soils presented complex foundation problems. Recently the **ST. JOHN BRANCH** was host to President Dr. B. G. Ballard. Members of this Branch returned to the classroom this year for a series of non-technical lectures as part of a newly-

(Continued on page 98)



launched Professional Development Program. Subjects being offered this term are public speaking, law, and industrial relations, each consisting of four lectures.

Toronto

J. D. Palmer, M.E.I.C.
Correspondent

The Canadian Regional Conference of the National Association of Corrosion Engineers was held January 17-19, in the King Edward-Sheraton Hotel.

The three-day program covered a wide rage of topics, including Non-Destructive Testing, Anodic Protection, Corrosion of Domestic Water Heaters, and Corrosion Problems in the Fertilizer Industry.

Speakers representing many industries presented papers detailing their experience in both Canada and the United States.

Many equipment and material suppliers had representatives on hand to provide literature and technical information. An informal cocktail hour after each day's technical session permitted registrants to discuss the technical topics and meet the expert speakers personally. The sessions were open to anyone interested in corrosion work.

Vancouver Island

W. Tivy, M.E.I.C.
Correspondent

Thirty-two members of the Branch enjoyed an interesting tour December 13 of the "City of Victoria", a ferry being built by the Victoria Machinery Deport for the British Columbia government. The "City of Victoria" will join the ferries "Sidney" and "Tsawwassen" on the Victoria to Vancouver run. The new ferry, about five weeks from completion at the time of the tour, is powered by four 1,700 hp. diesel engines and will be driven by two rear screws. She will also have a 500 hp. electrically driven bow propeller to facilitate docking.

Officers for 1962 were elected during the November 15 meeting. They include: Chairman, A. R. D. Robertson; Vice-Chairman, P. J. Croft; Secretary-Treasurer, W. Strok; and Executive members R. W. Lockie and R. E. Johnson. Executive members remaining from last year are J. Hicks and M. Zirel.

Following considerable discussion it was decided not to discontinue the Branch's annual $100 scholarship. It was further decided to establish a scholarship fund through raffles which will be held at the various Branch dinner meetings.

A joint meeting with A.P.E.B.C. was held November 21. Guest speaker was Professor F. A. Forward.

EIC

(Continued from page 91)

*FLOW OF FLUIDS THROUGH POROUS MATERIALS.

Primarily directed to petroleum engineers, this work provides a unified treatment of all aspects of all types of flow. It begins with an extensive treatment of the physical properties of porous materials. The theory of various types of flow is then developed, and various applications of the theory are presented. New and unpublished results are included on porosity and permeability distribution in sedimentary rocks, and on the calculations of water sweep patterns. (R. E. Collins. New York, Reinhold, 1961. 270p., $12.50.)

INVESTIGATION OF THE ACCURACY AND INTERFERENCE-IMMUNITY OF PHASE RADIO-DIRECTION FINDERS.

Comprising four papers translated from the Russian, this text covers research on radio direction-finding conducted at the Moscow Aviation Institute. The papers deal with apparatus errors in a two-channel pulse scheme, the effect of Gaussian interference; the influence of fluctuations in the amplitude of the reflected signal; apparatus errors in automatic shortwave radio direction finders. (V. B. Pestriakov, ed. West Newton, Mass., Friedman, 1961. 82p., mimeog., $7.50. no. P-164.)

(Continued on page 106)

(Continued from page 70)

such critical buckling loads, in practice this procedure is disguised through the use of hypothetical design stresses for columns which have no reasonable meaning or significance.

In conclusion, it must be asserted that the very great problems still remaining in the development of generally satisfactory and complete theories of structural behaviour and analysis, much less truly logical design, should not be allowed to obscure the significant advances in the development of scientifically sound concepts provided by the plastic limit theory.

References

1. J. F. Baker and J. W. Roderick, "Tests on Full-Scale Portal Frames", Proceedings, Institution of Civil Engineers, Part I, January 1952, pp 71-94.
2. J. F. Baker, "Shortcomings of Structural Analysis", Transactions, North East Coast Institutions of Engineers and Shipbuilders, v 68, pp 31-50 (1951).
3. J. Heyman, "On the Estimation of Deflexion in Elastic-Plastic Framed Structures", Proceedings, Institution of Civil Engineers, v 19, n 5, pp 39-60, (1961).

Author's Reply

The author is grateful to the distinguished panel of discussers who have found time to comment on his thoughts with regard to Plastic Design.

The author has found himself in strong disagreement with the view expressed particularly forcefully by Prof. Baker that in a structure designed elastically the unit stresses produced by all causes must not exceed the allowable stress. This, of course, is not so. It is not all stresses but only the ones which may be described as the load carrying stresses, that count in the conventional elastic design in nearly all cases. Stresses other than such are ignored. To these belong secondary stresses in trusses due to rigidity of joints, stresses due to local concentrations at the edges of holes and in the vicinity of sharply localized loads, stresses produced by cold bending and cold rolling of plates in fabrication of pipes and tanks, residual stresses caused by burning of holes and those present in rolled shapes. When Prof. Baker asserts that the elastic method predicts stresses badly he argues not against this method as employed by practicing engineers but against his own image of it.

The author has never come across a designer who would include the residual stresses caused by rolling in his calculations. It was for this reason that the author stated that the residual stresses were of no consequence in the elastic design. Accordingly, Professor Beedle's graph, Fig. 1, showing the effect of the residual stresses on buckling of beams is unrelated to the elastic design although it is significant in the plastic design.

The justification for ignoring the various secondary stresses in the elastic design comes from long engineering experience and not from the plastic theory. The latter, the rigid version of it, simply rationalized the well known favourable effects of the property of yielding.

When confronted with a new type of structure the designer must draw on his own engineering judgment and experience in his decision as to what stresses he may safely ignore. The absence of a hard and fast rule in this respect may be regretted, but the emphasis on experience in practice of elastic design is a general characteristic of the engineering profession.

With regard to the simple formula which Prof. Baker offers for estimation of the possible maximum effect of residual stresses on the load factor, the author simply cannot see how an expression of this kind can possibly take care of all the multiplicity of contributory conditions, such as the intensity and the manner of distribution of residual stresses; the type of structure: column, beam, rigid frame; the type of loading; dead, live or the combination of the two; the exact failure mechanism of perhaps a dozen different mechanisms possible; the fact that the rigid plastic collapse may correspond to one mechanism but the actual collapse to another. The author is frankly dubious of the alleged powers of the simple formula.

Prof. Baker states that both the elastic and the plastic designers have essentially the same task before them, namely, the investigation of the model of the structure. However, there is a great difference between the two cases. The elastician investigates his model (the idealized structure) under the action of the working loads, when the stresses are all elastic. Occasionally the problem of elastic instability comes in, which may be very difficult, as correctly pointed out by several discussers. But this is nothing like the problem confronting the plastic designer. In the first place the plastic model, according to the claims of the partisans of plastic theory, is the more economical and therefore the lighter of the two. What, however, is more important is the fact that this lighter model is stressed by a load 85% heavier than the working load, and that when under this load the model must be on the verge of collapse. This in turn implies that the stresses in the model are to a great extent plastic; stability must be analyzed under a difficult combination of partly plastic and partly elastic behaviour which is affected by all kinds of secondary stresses; the phenomenon of creep thrusts itself into a position of prominence and the considerations of the live load placement, influenced by the residual stresses from previous load applications, assume formidable proportions.

Furthermore, after the structure is designed by the empirical formulae given there is no way to find the true load factor. This is one of the principal points stressed by the author. Prof. Baker denies it irresolutely by saying "This is not really so" but he fails to amplify his statement. The author has searched in vain for such analysis in the 120 pages of the discusser's book devoted to non-rigid plastic method.

Another important criticism of the plastic theory was levelled on the loading condition for the design of columns. Prof. Baker specified in this connection that one floor beam at each of the two floor levels of the column should be plasticized by application of the full factored load, while the two other floor beams at the same floor levels should be loaded by factored dead loads. The author's prescription resulting in much greater column moments was to load all four beams by full factored loads and then remove the live load parts from two of the beams bringing them to the state of loading as specified by Professor Baker. The discusser vetoes this condition by asserting that the previous plastification of the two beams has produced in effect failure of the structure, making its subsequent behaviour of no significance. The author fails to see the line of Prof. Baker's reasoning in making this objection. A previous plastification is equally in evidence in the loading condition specified by him and is in fact the basis of all his non-rigid plastic theory of design of columns, especially with plastic end conditions.

Apart from this, one can imagine the beams involved to be loaded by a load 1% or 0.01% lighter than the failure load. Then they will not fail by Prof. Baker's standards but the resultant moments in the column will be virtually the same as calculated.

Prof. Beedle disagrees with the author's diagnosis of the two basic assumptions of his beam theory as unrealistic and unsafe. His discussion of this subject follows the line of the Commentary. The author feels that a few additional remarks may contribute to clarification of this point. Prof. Beedle contends that all material of structural steel under stress in yielding range is actually either in the elastic or in the strain hardening state, both of which are characterized by definite moduli of elasticity. If this statement means what it says, an increase in strain in the yielding range should bring with it an increase in stress at a rate intermediate between the values of the two moduli. Since however no such increase in stress takes place in the yielding range the discusser's supposition is manifestly incorrect. The gradual nature of extension of yielding from one slip band to another does not prove the proposition.

Deficient from the theoretical point of view, Prof. Beedle's formulae are claimed to be amply substantiated by tests. Experimental evidence in their support is

(Continued on next page)

impressive, but as always the case with empirical formulae there is danger of overstepping the limits of experiments.

The steel members tested were comparatively small, and little has been disclosed of the details of the tests, leaving ample room for uncertainties.

The readings of load and deformation were taken, it is stated, only after the conditions were stabilized. What does this mean exactly in terms of time? Creep in yielding and strain hardening regions may continue for months. How long did it take to perform the tests?

The value of yield stress of steel varies not only from beam to beam but also from web to flange and from one section to another in the same beam. How many control tests of yield stress were taken and how much room was there for subjective interpretation of test results?

An important question with regard to Prof. Beedle's formulae is, what exactly constitutes a lateral restraint. When criticizing the Commentary's example of rigid frame in Ref. 9, p.170, the author was dubious of the solution in which the restraints, computed by the slenderness ratio formula, were placed on the tension flange with no supports on the compression flange. Now in a counter-comment the discusser seems to admit that additional restraints on the compression flange are also needed, but he does not say how far apart. This clarification makes the meaning of lateral restraint in the Commentary's formulae so obscure that the author does not see how a designer can use the formulae.

The discusser's comments on the design of connections do not explain how a stress 20% greater than the yield stress arrives at the beam flanges. His method of design is again justified solely on the strength of experimental evidence.

The author wishes to make it clear that his criticism is directed on the present status of plastic theory and not on its aim, and that he holds in highest regard the untiring efforts of the principal proponents of the theory, Prof. Baker and Prof. Beedle, even though he does not agree with them in the appraisal of their findings.

Prof. Benjamin's word of warning in connection with the empirical nature of plastic formulae and the limited experimental evidence, coming largely from a single source may very well be pondered upon by those responsible for the proposed inclusion of the plastic theory in specifications. Hasty acceptance of the new theory before a thorough examination of its many phases and the resolution of its difficulties does not seem to be in line with the traditional caution of the engineering profession.

The discussions of Professors D. T. Wright and W. J. Sutcliffe have the effect of neutralizing each other. Prof. Wright is a great believer in the alleged superiority of the Plastic Theory over the Elastic Theory, while Professor Sutcliffe holds the opposite view.

EIC


caron
SERVING CANADA THE NORTHERN WAY

(Continued from page 96)
of central station air conditioning systems, the packaged Tonrac provides chilled water for operation of zone or individual room conditioners in hospitals, schools, small offices and industrial plants, motels and small hotels and other buildings of similar nature.

A NEW DUO-SEAL Vacuum Pump, the 1398, has been developed by the Welch Scientific Company. The new pump has capacities in excess of 50 CFM, or 1,400 li. min., and pressure down to 1×10^{-4} mm Hq (McLeod) or better. These Duo-Seal Pumps are completely run-in at the factory and have been tested until they exceed their vacuum guarantees. The 1398 is especially recommended for applications requiring high pumping capacities and low pressures. Typical uses of this pump are vacuum distillation, dehydration, reduction, leak detection and hermetic sealing.

PRODUCTIVE EFFICIENCY at United Steel Corporation Limited has been effected by consolidating so that all subsidiaries become divisions. Engineering services of the company are being consolidated and centralized. Greater emphasis upon engineering will be placed to increase efficiency for the customers' benefit. The result of the consolidation is a more streamlined organization to deal with prospected expansion of business.

FOR HIGHLY CORROSIVE pumping jobs involving small capacities, up to 75 GPM, M. L. W.—Goulds has put a one inch MLW-Goulds-Pfaudler glassed pump on the market. This unit is designed to fill the demand in the chemical processing industries for a unit of lower capacities than available with the Model 3706 MLW - Goulds - Pfaudler glassed pump first introduced in 1956. Glass, fused to metal on all surfaces coming in contact with the pumpages, provides almost complete resistance to corrosion. As the bonded glass is tough and the glass surfaces are continuous with no bolt holes or tapped openings contamination of product is eliminated.

PRELIMINARY EVALUATIONS have shown Canadian General Electric research scientists that silicone rubber materials have excellent heat resistance for short periods at temperatures up to 9,000° F. From these preliminary evaluations vital information has come. Results indicate that silicone rubber can be used as thermal insulation on missiles and space vehicles. This is due to the formation of a hard carbon layer which protects the underlying surfaces. This phenomenon indicates that silicone rubber can be used in other applications where similar characteristics are required.

A NEW COMPACT unit for the Gardner - Denver SP125 Rota - Screw Compressor is now available for mounting on any style truck bed. This packaged unit, designed particularly for the public utility service features automatic starting and blow-down and flawless operations in all weather from 40° below to 115° above zero. All controls and instruments are mounted on one end of the machine behind a drop rear door. Currently in production the Rota-Screw has no metal-to-metal contacts in the compression chamber.

AN ANALYSIS of nine important factors governing the production of high quality concrete is treated in a six page publication by Master Builders Company. The booklet, P-36A, outlines the ability of Pozzolith to give concrete increased flexural, bond and compressive strength, effectively entrained air, increased workability and durability, initial retardation and resistance to scaling. Charts, graphs and photographs based on field and laboratory tests illustrate the brochure.

THE EXPLOSIVES division of Canadian Industries Limited is investigating the possibility of establishing a mixing plant for the production of a newly-developed type of blasting agent. The plant would be located in Sudbury, Ont. If plans are approved the plant should be completed within the first half of the year. It would supply the local Sudbury area as well as other northern mining districts requirements for ammonium nitrate fuel oil type blasting agents.

AN EXTREMELY small fission counter with a flexible coaxial cable designed for thermal neutron fluxes up to 10 neutrons/cm^2-second, or 10^8 nv. Less than

¼ in. in diameter and less than 33 in. long the device has a six-ft. length of ⅜ in. diameter coaxial cable attached, though a longer one can be supplied on special order. All metal parts are titanium to insure low activation and the WX-4706 is insulated with high-purity vacuum sealed ceramic.

ONTARIO HYDRO is building a 50-mile transmission line between the northern Ontario communities of Manitouwadge and Hornepayne by air. Helicopters will be used in all phases of construction. They will carry wood poles, set them in the ground and string conductors. Personnel will also be moved by helicopter as only a small part of the line's right-of-way is accessible by road.

INDUSTRIAL Equipment Limited has opened a plant in Clarkson, Ont. DEMAG—for Deutsche Maschinenfabrik Aktiengesellschaft — produces electric hoists, suspension tracks and suspension cranes, stacker cranes, overhead travelling cranes, mobile cranes, grabs, load lifting magnets, multiple magnet spreader bars, motors and standard components needed by industry.

THREE NEW COMPRESSORS have been announced by Canadian Ingersoll Rand Co. Limited. The "Spot-Air" delivers 36CFM of air at 80 psi with little or no maintenance. This compressor, self contained and completely portable is 32 in. high and 27 in. in diameter, and weighs 265 lbs. Three power cylinders are driven by an air-cooled four-cycle gasoline engine. The "Spot-Air" can be used for a variety of applications. The two new compact Power Take-Off Gyro-Flo Compressors, the RS-85 and RS-125 have been designed for utility services or any other air power application where compact trucks and equipment are a necessity. Both consist of compressor, oil cooler and accessories — compactly mounted on a rigid baseplate and are driven by the truck engine through either direct or belt drive from the truck power take-off. The RS-85 weighs 455 lbs. while the RS-125 weighs 680 lbs.

TWO FULLY compatible solid-state units can send or receive scientific or business data over leased communications lines at up to 300 characters per second—30 times the speed of human speech. Data can be sent in the following ways: card to tape, tape to card, card to memory, memory to card, tape to memory, memory to tape, card to card, tape to tape and memory to memory. The IBM 7702 magnetic tape transmission terman will transmit and receive data from magnetic tapes used by most IBM data processing. The IBM 1013 card transmission terminal which has been buffered for the grouping of data in blocks of up to 329 characters, operates under the control of a stored program that determines the format in which data is transmitted. It reads cards at the rate 700 characters a second, transmits data at the rate of 300 characters and punches cards at the rate of 80 characters a second. Both new units automatically detect and correct reading and writing errors as well as errors in transmission. A special operating routine permits data containing a permanent error to be bypassed.

A DRILLING MACHINE known as the Bantam has been introduced to the Canadian market by Atlas Copco Canada Ltd. This unit bridges the gap between the plugger and the wagon drill. It is especially designed for use where drill holes must go too deep for a conventional plugger but not deep enough for the economical use of a wagon drill.

A NEW TANKER, as yet unnamed, is being built by Canadian Shipbuilding and Engineering Co. Ltd., Collingwood, Ont., for Canadian Oil Companies Ltd. The biggest addition to Canadian Oil's transportation system since 1948, the tanker will have a speed of 12¾ knots, a pumping capacity of 8,000 barrels an hour and a carrying capacity of 51,000 barrels of gasoline when fully loaded. A feature of the design is 10 separate cargo tanks permitting the vessel to carry five separate products simultaneously without the possibility of intermixing

(Continued on page 108)

(*Continued from page 98*)

*SYMPOSIUM ON ELECTRODE PROCESSES, TRANSACTIONS.

The papers included in this volume were presented at an international symposium sponsored by the Electrochemical Society and the U.S. Air Force Office of Scientific Research. While virtually all phases of fundamental investigations of electrode processes are covered, emphasis has been placed on new research developments, and more specifically, on hydrogen discharge kinetics, electrodeposition and dissolution of metals, the electrical double layer, adsorption phenomena, and the kinetics of fast electrode processes. (Ernest Yeager. New York, Wiley, 1961. 374p., $20.00.)

*WATER HAMMER IN HYDRAULICS AND WAVE SURGES IN ELECTRICITY.

This classical work presents a graphical method for the solution of highly complex problems dealing with water hammer. The author also discusses the use of this method to solve problems dealing with metallic bars subjected to longitudinal forces, transverse waves in a stretched string, torsional waves in a rotating cylinder, variations of discharge in an open channel, and surges on electric lines. A variety of practical examples are given to illustrate the application of this method to specific situations. (Louis Bergeron. New York, Wiley, 1961. 293p., $15.00.)

*MANAGEMENT MODELS AND INDUSTRIAL APPLICATION OF LINEAR PROGRAMMING. VOL. I.

The underlying theory of linear programming is presented and illustrated by concrete examples drawn from actual experience in managerial, engineering, and economic applications, These applications are incorporated into a unifying theme identified as the idea of "model types". Accompanying geometric representations are included wherever possible as a further aid to intuition and understanding. The mathematics is restricted for the most part to algebra. (A. Charnes and W. W. Cooper. New York, Wiley, 1961. 467p., $11.75.)

*METALLIC FATIGUE.

The major factors which affect the fatigue behavior of metals are surveyed. Theoretical treatments are given of such factors as stress concentration, frequency effects, corrosion, fretting, crack propagation, and statistics. Particular emphasis is placed on the relationship of metallic fatigue to standard aircraft fabrication and finishing processes, and a wide range of testing machines and apparatus are described. (W. J. Harris. Oxford, Pergamon, 1961. 331p., $12.50).

*STRESS CONCENTRATION AROUND HOLES.

The problem of stresses set up around holes of various shapes in beams and plates subject to different kinds of loading is discussed at length. The most important results on stress concentration are clearly compiled as graphs and tables, thus enabling engineers and designers to arrive at conclusions of significance without having to make a detailed study of the theory. A translation from the Russian, this work consists mainly of the results of the work of the author and his students over a period of fifteen years. (G. N. Savin. Oxford, Pergamon, 1961. 430p., $15.00.)

*AN INTRODUCTION TO APPLIED ANISOTROPIC ELASTICITY.

The problems encountered in anisotropic elasticity, the methods of solving them, and the results obtained are discussed. The topics discussed include elastic constants and symmetry, elastic constants of single crystals, sheet materials and polycrystalline aggregates, simple stress systems, stress and strain distribution, wave propagation, and anisotropic plates. Although the subject matter has evolved largely along mathematical lines, the book is intended primarily for physicists and engineers, rather than for mathematicians. (R. F. S. Hearmon. Toronto, Oxford, 1961. 136p., $5.25.)

***ETUDE ET DETERMINATION DES SYSTEMES HYDRAULIQUES.**

This text covers both the static and dynamic characteristics of hydraulic elements and systems, including hydraulic servo-control mechanisms. Considerable space is devoted to calculations, including nine practical problems for which detailed solutions are provided. There is also a group of nomograms and other charts, seven of which are reproduced on transparent paper for direct use. (M. Guillon. Paris, Dunod, 1961. 443p., 78NF.)

***PROGRESS IN CRYOGENICS, VOLUME 3.**

A critical review of new developments in the field of cryogenics, this volume covers helium liquifiers, low temperature heat exchangers, novel refrigeration cycles and devices, cryogenic rocket propellants, paramagnetic substances for nuclear orientation, and dynamic nuclear orientation. (K. Mendelssohn. New York, Academic, 1961. 173p., $8.00.)

***INTRODUCTION TO THE DYNAMICS OF AUTOMATIC REGULATING OF ELECTRICAL MACHINES.**

The general laws governing the design and development of automatic regulating systems are discussed, and methods for their analysis and synthesis are presented. The first twelve chapters are devoted to the linear systems with continuous action. Of these, the twelfth chapter is entirely taken up with the discussion of concrete examples, the selection of a network configuration, and the computation of the basic parameters. The theory of intermittent regulation is then discussed, and the remainder of the book is devoted to non-linear problems in the theory of automatic regulating. (M.V. Meerov. Toronto, Butterworths, 1961. 411p., $18.75.)

***CIVIL ENGINEERING REFERENCE BOOK, 2nd. ed.**

An extensive reference work covering all phases of civil engineering. This edition includes new chapters on hydraulic power plants, overhead transmission lines, structural concrete, prestressed concrete, masonry and brickwork, and the aesthetics of bridge design. Some chapters have been completely rewritten, either by the original contributors or by new contributors. All other chapters retained from the first edition have been thoroughly revised. In addition the entire work has been rearranged for greater convenience. (J. Comrie, ed. Toronto, Butterworths, 1961. 4 vols. $66.50.)

COMPUTER ANALYSIS OF CYLINDRICAL SHELLS.

Sets of design tables for 286 types of shell roofs calculated by the computer at the University of Manchester, the aim being to give an example of most of the shells which an engineer might be called on to design. Given the span, length and radius of the structure, the designer can find the bending moments and forces in edge beams, and forces and moments at all quarter points of the shell. From this, the reinforcement can be designed. The tables cover single shells with edge beams, multi-shells with edge beams; multi-shells with prestressed edge beams. Multiplying factors for increased snow load are given in an appendix. This volume is intended as a supplement to the author's Design of Cylindrical Shell Roofs. (J. E. Gibson. London, Spon, 1961. 259p., 84/-.)

COURS DE MATHEMATIQUES.

Intended for undergraduate engineering students, this text provides a course in mathematics, showing their application to engineering, rather than being a course in applied mathematics. The first volume covers linear algebra, functions, simple integrals, Fourier integrals, curves, surfaces, multiple integrals. The second volume deals with analytical functions, linear equations, differential equations, partially derived equations, harmonic functions. Problems and extensive bibliographies are included. (J. Bass. Paris, Masson, 1961. 2 vols., 104 NF.)

(Continued on page 109)

THE CANADIAN COMMITTEE ON LARGE DAMS
WORLD REGISTER OF DAMS

The Canadian Committee on Large Dams (CNC/ICOLD) is assembling data on all large dams in Canada as part of a world wide effort to publish a World Register of Dams.

Government authorities, corporations and engineering firms across Canada have been approached during the past year for details of dams which they own, operate or have designed.

The response has been excellent and, to date, information on 297 dams which qualify for the register, has been assembled.

The project is now moving into its final stages and the Canadian National Committee hopes to have its section of the World Register ready for publication early in 1962. However, it is recognized that there may be additional dams of which the Canadian National Committee is not aware. The Committee would, therefore, be grateful for any information on little known dams which readers suspect may not have been brought to the Committee's attention.

All dams 50 feet high or more will be included in the Register and dams from 33 feet to 50 feet will be included subject to certain other qualifications.

(Continued from page 105)

A NEW CHROMATOGRAPHIC analyzer made by The Foxboro Co. provides measurements of up to six components on which to base control of process stream composition. Continuous measurement trends are monitored by two pneumatic recorders, each logging the concentration of three components. Sharp peak definition has been achieved largely through a sampling valve which delivers a uniform slug of sample gas to the column for each analysis.

A CONDENSED CATALOGUE of industrial process instruments has been published by Honeywell Controls Ltd. This catalogue describes electronic instruments, Electrik and pneumatic Tel-O-Set lines, millivoltmeters, primary sensors, filled system thermometers, pressure gauges and transmitters, flow and liquid level meters, Out-O-Pulse telemetering systems, special purpose instruments, computers and data handling systems, basic industrial controls, and control valves.

A CONTRACT for five control gates and operating equipment to be added to the international control dam on the upper Niagara River has been awarded Ontario Hydro. Dominion Bridge Co. Ltd., of Toronto will supply the gates and machinery. The existing 13-gate control dam, about one mile above the Falls, was completed in 1957. The contract is valued at more than $750,000.

(Continued from page 107)

*MATHEMATICAL HANDBOOK FOR SCIENTISTS AND ENGINEERS.

This is a comprehensive reference collection of mathematical definitions, theorems and formulas for scientists, engineers and students, including both undergraduate and graduate level material. Proofs are omitted, and related formulas are presented in concise tables, enabling compact treatment and a special arrangement of topics. This special arrangement, within each chapter, is such that a terse, connected review of each subject is accomplished. Numerous references also are given to provide access to other material for more detailed studies. Six appendices contain numerical tables, tables of integrals and Fourier expansions, and other useful data. (G. A. Korn and T. M. Korn. Toronto, McGraw-Hill, 1961. 943p., $23.00.)

*BOUNDARY LAYER AND FLOW CONTROL.

This work contains contributions by 38 authorities and encompasses the entire field of the subject. Its various sections cover the history of boundary layer and flow control research in various countries; boundary layer and flow control to prevent separation and/or increase lift in subsonic flow; boundary layer control for low drag in subsonic flow; and shock-induced separation and its prevention by design and boundary layer control. Emphasis is on engineering applications. (G. V. Lachmann. Oxford, Pergamon, 1961. 2 vols. $35.00.)

GUIDE POUR LA PRATIQUE DES RELATIONS PUBLIQUES.

Translated from the English edition published by the British Institute of Public Relations, the text has been adapted for French readers. It is a guide to public relations for companies and other organizations, and commences with a definition of public relations, their aims and functions and problems. Following chapters cover public opinion; media, press, photographs, radio, television, movies, exhibitions, etc.; public relations in the government, both central and local; public relations for professional organizations. (Paris, Dunod, 1961. 374p., 48 NF.)

MANUEL D'ANTICORROSION. t. 1
INTRODUCTION A L'ESPRIT DE LA TECHNIQUE D'ANTICORROSION.

Intended both for those specializing in the problems of corrosion, and those faced with the problem in connection with one particular project, the work covers both the theory of corrosion and methods of combatting it.

This first volume commences with an outline of the causes of the various types of corrosion; chemical, atmospheric, water, metal fatigue, and wear; corrosion and atomic energy. Other topics covered include: passivity; cathodic protection; anti-corrosion materials; treatment of industrial water supply.

A second volume will deal with what might properly be called the technology of anti-corrosion. (A. J. Maurin. Paris, Eyrolles, 1961. 349p., 61.80 NF.)

STEEL FRAME DESIGN EXAMPLES.

Intended primarily for students at an intermediate level, this volume should also prove useful to practising engineers. It is a practical treatment of steel frame design using the latest British Codes of Practice. As the reader is assumed to have basic knowledge of the subject, only a revision is given of elementary design principles, and the author also covers briefly specifications, choice of sections, and cost factors. Most of the book consists of a series of examples, with calculations and detailed drawings of various types of industrial buildings, including a multi-storey store, a 60 foot span shed with rigid-type roof trusses; a large-span building with lattice girders; a braced tower supporting a water tank. (Ian Robb. London, Cleaver-Hume, 1961. 215p., 30/-.)

EIC

Consulting Services

Alchem LIMITED,

BURLINGTON, ONTARIO

Specializing in water treatment, petroleum inhibitors, fuel catalysts, papermaking chemicals and allied metallographic, microbiological and other services.

ASSOCIATED ENGINEERING SERVICES LTD.

Consulting Engineers

MUNICIPAL SANITARY INDUSTRIAL STRUCTURAL

Surveys, Town Planning, Reports, Supervision

REGINA	EDMONTON	VANCOUVER
1233 Winnipeg St.	12225-105 Avenue	2256 West 12th Avenue

BEAUCHEMIN — BEATON — LAPOINTE

CONSULTING ENGINEERS

Reports • Estimates • Design • Construction Supervision
for public works, municipalities, and industry

6655 COTE DES NEIGES ROAD MONTREAL 26, CANADA
REgent 1-8521

CANADIAN BRITISH ENGINEERING CONSULTANTS

Water Supply and Purification
Sewerage and Sewage Disposal
Treatment of Industrial Wastes
Harbour and Rivers Engineering

Toronto 19, Ont. 3089 Bathurst St.
Ottawa, Ont. 46 Elgin St.
Halifax, N.S. 513 Barrington St.
St. John's Nfld. 191 Water St.

C. D. CARRUTHERS & WALLACE, CONSULTANTS LIMITED

92 Yorkville Avenue
Toronto 5

Consulting Structural Engineers

COODE, BINNIE & PREECE

Consulting Civil Electrical & Mechanical Engineers

Reports, Designs, Supervision, Docks & Harbours: Bridges: Water Supply & Drainage: Flood Protection & Irrigation: Sewerage Schemes: Hydro-Electric & Thermal Power.

36 Roxborough Apartments, Ottawa 4, Ontario

Telephone: Central 4-4674

CRIPPEN WRIGHT ENGINEERING LTD.

Engineering Consultants

Investigations, Designs, Supervision
Hydro Electric Developments, Water Supply Projects
Industrial Structures, Bridges, Dams, Electric Power

207 West Hastings Street Vancouver, Canada

EDGAR A. CROSS & ASSOCIATES

Consulting Engineers

INDUSTRIAL PLANT DESIGN

2510 YONGE STREET, TORONTO HU. 1-1139

DILWORTH SECORD MEAGHER & ASSOC.

LIMITED

Consulting Engineers

SPECIAL MACHINERY & EQUIPMENT, CONTROLS, RESEARCH FACILITY PLANNING, TURBO MACHINERY, NUCLEAR ENGINEERING, AIR POLLUTION.

Analyses • Experimentation • Design • Supervision

4214 DUNDAS ST. W. TORONTO 18, ONTARIO

V. DOLMAGE & D. D. CAMPBELL

Engineering and Mining Geologists
Foundations, tunnels, dam sites, ground water and mining.

1119 Marine Bldg. Vancouver, B.C.

Telephone: MUtual 5-9736
5-0936

J. T. DONALD & CO. LIMITED

CHEMICAL AND ENGINEERING SERVICES

ANALYSTS and ASSAYERS

1181 GUY STREET, MONTREAL, QUE.

ENGINEERING SERVICES LIMITED CONSULTANTS

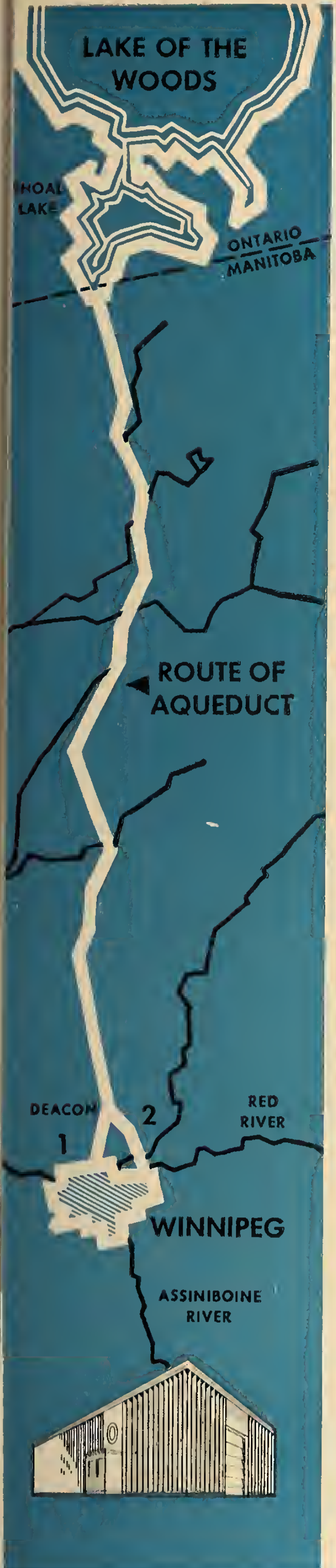
Water Supply and Treatment
Sewerage and Sewage Treatment
Municipal Engineering

SURVEYS • REPORTS • DESIGN

Construction Supervision

P.O. Box 564 Phone 94223
169 Elizabeth Ave., St. John's, Newfoundland

Denotes Membership of a Principal in the Association of Consulting Engineers of Canada

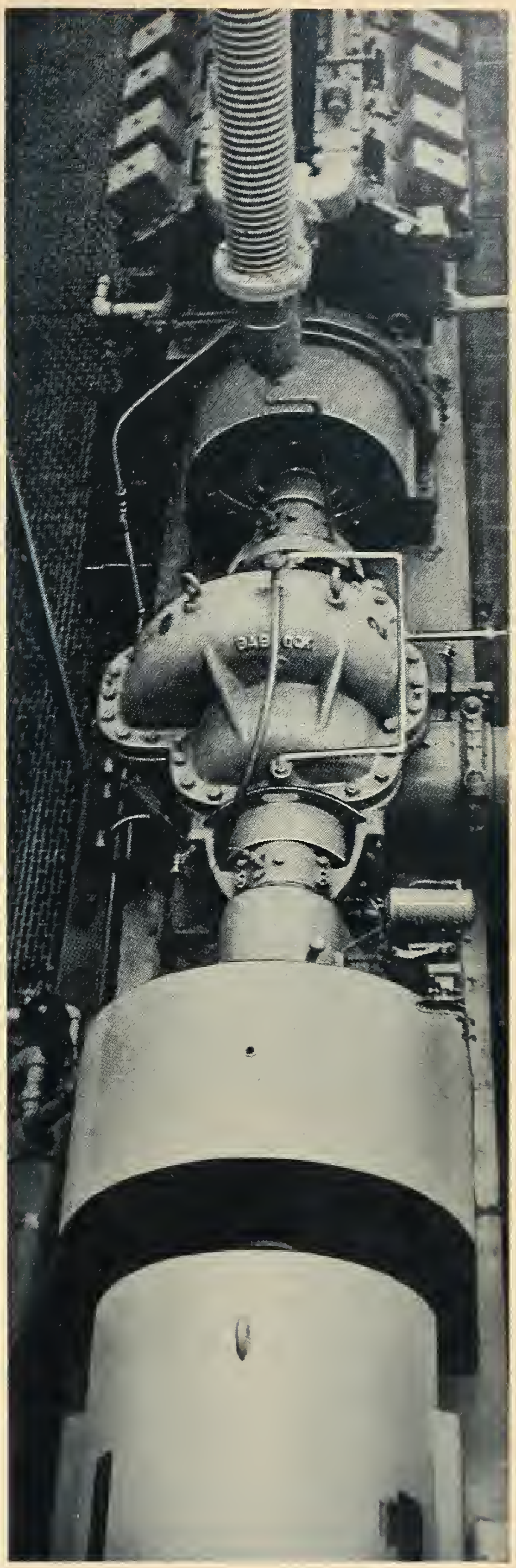


In step with expanding demands the City of WINNIPEG INSTALLED FIVE B&W PUMPS

The Metropolitan Corporation of Greater Winnipeg carries the responsibility of supplying pure water to the Cities of Winnipeg and St. Boniface and suburban municipalities. The water flows 97 miles from Shoal Lake to the city's reservoirs; from that point the City of Winnipeg disinfects and pumps the water to its distribution system and to the distribution system of ten suburban cities, towns and municipalities.

To assure adequate supply and pressure for present and future needs, 5 B&W pumps were installed in the modern, unattended W. D. Hurst Station ... here a supervisory and automatic control system governs pressure, flow and other variables.

For information about pumps 'phone or write the nearest B&W Office . . . there's a B&W representative qualified to discuss pumps for any application.



Illustrated: One of the dual driven B&W Pumps in the W. D. Hurst Station. Two pumps are constant speed motor driven, 12,500 USGPM capacity at 165' head. The other three pumps are variable speed; dual driven by motors (fluid drive) and natural gas engines; 8330 USGPM capacity at 165' head.

B&W

PUMP & TURBINE DIVISION

BABCOCK-WILCOX and GOLDIE-McCULLOCH LIMITED, GALT, ONTARIO

MONTREAL · TORONTO · CALGARY · VANCOUVER

Atlantic Provinces Agent—Foulis Engineering Sales Limited, Halifax, N.S.

INDEX TO ADVERTISERS

JANUARY 1962

PUBLICATION OFFICES: The Engineering Institute of Canada, 2050 Mansfield Street, Montreal 2, Quebec, Canada.

Association of Consulting Engineers of Canada Incorporated

The following firms have principals who are members of this Association engaged as professional engineers in engineering work independent of salaried employment or sales promotion.

The revenue derived from the sale of advertising space assists the Institute in publishing THE ENGINEERING JOURNAL on a regular monthly basis. Listed above are the names of the Companies and individuals whose advertisements appear in this issue.

ADVERTISING OFFICES

QUEBEC: J. E. Donovon, Monoger, Advertising Soles—D. W Compbell, 2050 Monsfield Street, Montreal, Phone: VIctor 2-8121
ONTARIO: L. G. Bornum, Manager, Advertising Sales, 804 Mount Pleasant Rd., Suite 4, Toronto, Phone: 485-0789
VANCOUVER: Eric Lindsay, 545 Thetford Ploce, West Voncouver, B.C. WAlnut 2-1415
MANITOBA: W. George Turner, 501 - 191 Lombard Ave., Winnipeg, Mon., WH 3-9123
EUROPE: H. A. Mockenzie, 4A Bloomsbury Square, London, W.C.1, Englond. Phone: HOlborn 3779
NEW ENGLAND STATES: R. G. Melendy, 17 Mougus Avenue, Wellesley Hills 81, Mass. Phone: CEdor 5-6503
CHICAGO: W. Reynold Rotz, 549 W. Rondolph St., Chicago 4, Ill. Phone: ST-2-8811
NEW YORK: John H. Boyd, 17 Eost 45th Street, New York, Phone: MUrroy Hill 7-0654

THE
ENGINEERING JOURNAL
VOLUME 45 NUMBER 2 FEBRUARY 1962

PUBLISHED MONTHLY BY THE ENGINEERING INSTITUTE OF CANADA, 2050 MANSFIELD ST., MONTREAL 2, QUE., CANADA • TEL. VI. 2-8121

Printed in Toronto

Price $6.00 a year in Canada, British Possessions, United States and Mexico, $7.50 a year in Foreign Countries. Current issues, 75 cents a copy, back issues from $1.00 per copy up. To members, affiliates and other bona fide engineers in Canada—no charge. Authorized as second class mail, by the Post Office Department, Ottawa, and for payment of postage in cash.

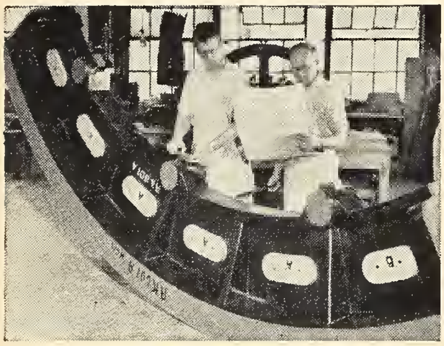
MEMBERSHIP

CCAB

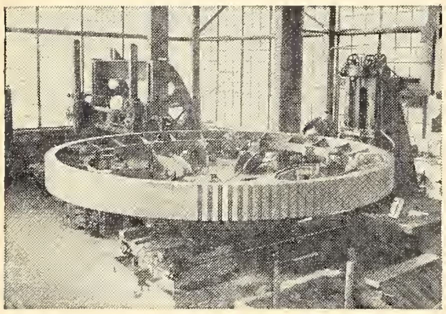
Indexed in
The Engineering Index
The Applied Science and Technology Index

CONTENTS

The quarter section pattern being constructed in the completely equipped pattern shop.

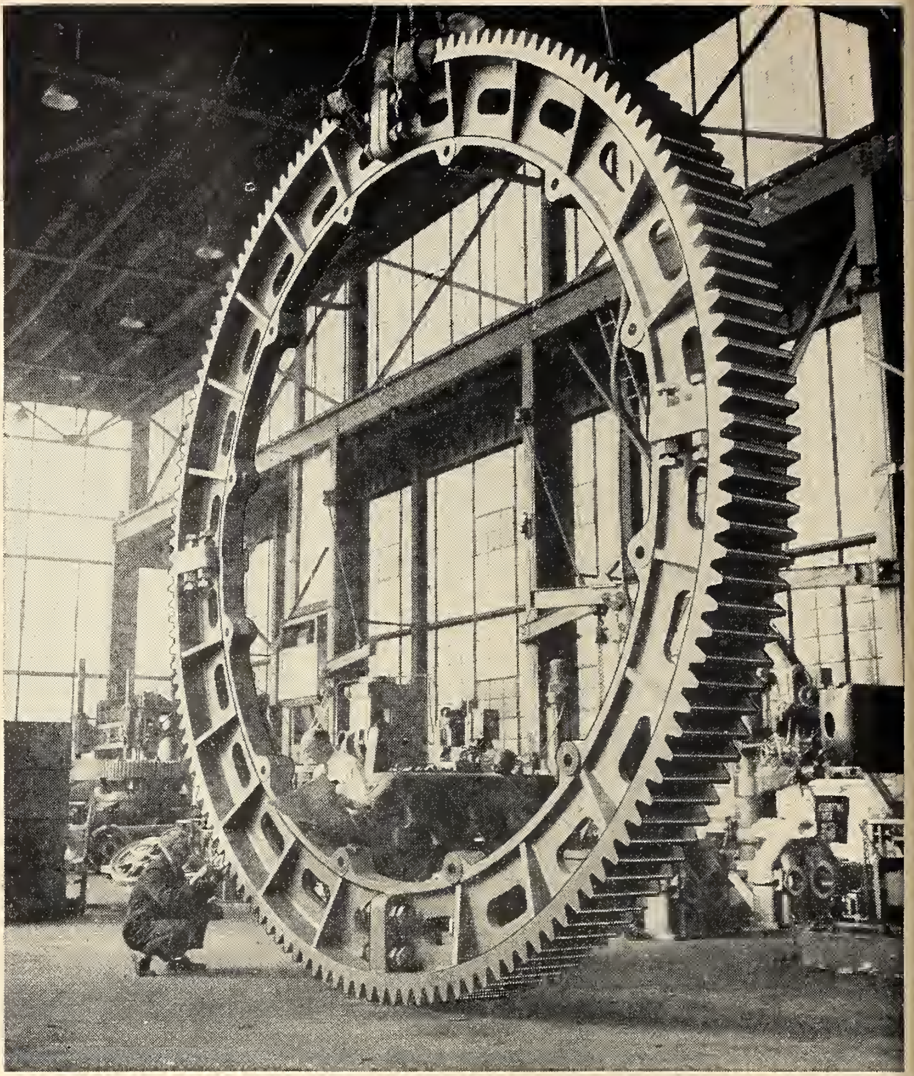


Completed quarter section pattern on final inspection before shipment to steel foundry for casting.



First roughing operation on gear cutting machine.

Final inspection and detail check prior to release for shipment to the customer.



The Story of a 20 Foot Gear

(and Hamilton Gear Made it)

Hamilton Gear has just completed the largest spur gear ever built in Canada. There were four of these 20 foot steel giants and they presented many complex problems, but Hamilton Gear's complete facilities—from pattern shop to finished gears—handled them as just another routine order. The only basic difference—these gears were bigger.

Gears, whether "giant size" or "normal" are Hamilton Gear's only business. Their complete equipment, engineering facilities, and experience as Canada's foremost gear manufacturers make them the logical suppliers for your gear requirements.

Hamilton Gear
and Machine Company

CEL

A MEMBER OF THE COMBINED ENTERPRISES GROUP

TORONTO — 950-990 Dupont St.
MONTREAL — 6785 Upper Lachine Road
WINNIPEG — The Cuthbert Company Ltd., 19 McPhillips St.
EDMONTON — John Ross and Co. Ltd., 6803 - 104th St.
VANCOUVER — B.C. Conveying Machinery Ltd., 8265 Fraser St.

IN THIS ISSUE

In his paper, *"The Hydraulic Capacity of Large Corrugated-Metal Culverts"*, **C. R. Neill**, Hydraulic Engineer, Research Council of Alberta, describes the research program and field experiments carried out by the Bridge Branch of the Alberta Department of Highways. This program was initiated under the auspices of the joint Highway Research Project in Alberta including the Department of Highways of the province, the Research Council of Alberta, and the Civil Engineering Department of the University of Alberta, for the experimental checking of existing hydraulic design information and also for a more convenient form of presentation. This paper also describes the development of a method of analysis which enables head-capacity charts to be produced for all sizes, lengths, and slopes.

"Factors Involved in the Design of a Canadian Gangsaw" by **E. N. Parker**, M.E.I.C., contrasts the operation of saws used in lumber production in Canada, with the operation of gangsaws used extensively in Europe and in North America under different operating conditions. He discusses the various types of saws available, and outlines the factors affecting the users' choice of a saw. Service conditions affecting the design, and a description of the components and their function in a typical gangsaw are given. The design considerations for the various parts of the saw are reviewed and the choice normally available concerning the selection of materials and the placement of components is outlined. Power sources and requirements for operating the saw are also mentioned.

The latest revisions to the concrete and reinforced concrete requirements of the National Building Code 1960 are discussed in, *"Revision of the Concrete Section of the National Building Code."*

The paper reviews briefly the history of standard regulation on concrete in Canada and, in reviewing the latest revisions to the NBC, points out those areas in which further study is needed. **Mark Williams Huggins**, M.E.I.C., Professor, Department of Civil Engineering, University of Toronto, received an M.A.Sc. at the University of Toronto in 1933. From graduation until 1938 he was with E. P. Muntz Ltd. and the Dominion Bridge Company. For the next three years he was a lecturer at Queen's University. From 1941 to the present he has been associated with the University of Toronto. Mr. Huggins is a partner in the firm of consulting engineers known as Morrison, Hershfield, Millman and Huggins. He is a past chairman of the Toronto Branch of E.I.C. and a past councillor of E.I.C. He was chairman of the Revision Committee, NBC 1960, and the CSA committee on prestressed concrete. **William Gordon Plewes**, M.E.I.C., co-author of this paper, is Associate Research Officer, Division of Building Research, of the National Research Council, Ottawa. He was born in Manitoba and received his early education there. Following two years in the Accounting Department of the Canadian Pacific Railway and four years in the RCAF, Mr. Plewes obtained his B.Sc. in Civil Engineering from the University of Manitoba in 1949 and M. Appl. Sc. from Queen's University in 1954. From 1949 to 1952 he was engaged in the design of bridges and buildings with the Canadian National Railways, and from 1952 to 1954 was lecturer at the Royal Military College, Kingston, Ont. Mr. Plewes joined the Division of Building Research of the National Research Council in 1954 and has since been engaged in structural research.

In recent years it has become essential to consider random variables in the design of many engineering systems, with consequent modification of classical design procedures which were based upon steady-state, sinusoidal or transient inputs. **J. H. Milsum**, Head of the Analysis Section, Division of Mechanical Engineering, National Research Council, in Ottawa, discusses this in his paper *"Treatment of Random Variables in Engineering Design"*. Most natural signals affecting engineering systems are partially random. In control systems, the randomness is propagated around a closed loop. Analytic design is possible for linear systems but in the more realistic non-linear case approximate methods are required unless solution is made by computer. For engineering purposes there are two essential measures of stationary random signals—the amplitude probability density (APD) and the power spectral density (PSD) or its Fourier transform, the auto-correlation function. Some commonly encountered APD's are presented in the paper, PSD's are introduced and the mathematical relation for filtering of PSD's by dynamic systems is discussed. The experimentally-determined characteristics of several natural signals are discussed.

ERRATA

A technical paper entitled *"Sewage Stabilization Ponds for the City of Saskatoon"* by D. R. Stanley and E. J. Cole which was published in the January, 1962, issue of the Engineering Journal was omitted, in error, from the Index Page of the Journal. We regret this omission and apologize for any embarrassment it might have caused the authors.

COVER ILLUSTRATION

Shown is the installation of an 18-foot diameter corrugated-metal culvert being installed at Ste. Rose, Quebec, on the Laurentian Autoroute. (Photo courtesy Armco Drainage & Metal Products of Canada Ltd.)

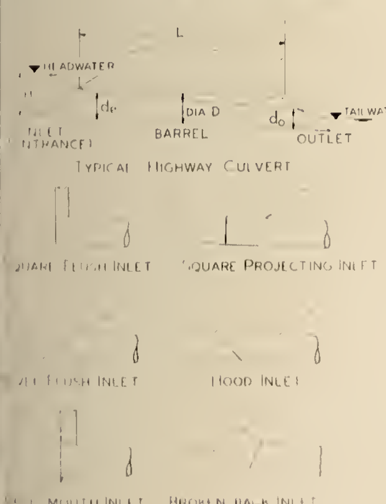
HYDRAULIC CAPACITY OF LARGE CORRUGATED METAL CULVERTS

C. R. Neill, M.E.I.C.,
Hydraulic Engineer, Research Council of Alberta

Presented at the 75th E.I.C. Annual General Meeting, Vancouver, May 1961.

N DESIGNING corrugated-metal culverts, engineers customarily se either the slope-capacity charts ublished in the handbook of the eading manufacturer, or the head-apacity nomographs issued by the J.S. Bureau of Public Roads. Both of hese sources of design information ave certain deficiencies, and are pt to be used indiscriminately for roblems to which they are not really pplicable. Believing that there was eed for experimental checking of existing hydraulic design information, and also for a more convenient form of presentation, the Bridge Branch of the Alberta Department of Highways recently initiated a research program into the problem, undertaken under the auspices of the Joint Highway Research Project in Alberta, which includes the Department of Highways of the province, the Research Council of Alberta, and the Civil Engineering Department of the University of Alberta as participating bodies. This paper describes the field experiments carried out to date, and the development of a method of analysis which enables head-capacity charts to be produced for all sizes, lengths, and slopes.

Fig. 1. Typical culvert details

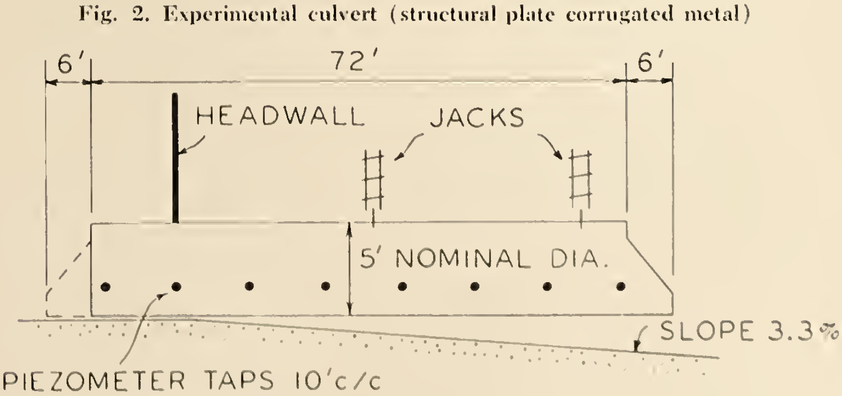


Theory

Sketches of a typical highway culvert, and of various types of inlet which are either in common use or have been proposed by research investigators, are shown in Fig. 1.

The discharge through a culvert with a free outlet, i.e. where the tailwater is sufficiently low to have no retarding effect on the flow inside the culvert, is determined primarily by the headwater depth (H) and by the size and shape of the inlet. If the discharge is determined by these factors alone, the culvert is said to be operating under "inlet control". It has generally been assumed for design purposes that most highway culverts operate in this way, and within

Fig. 2. Experimental culvert (structural plate corrugated metal)



This paper was prepared for presentation a year ago. Since that time a great deal of extra work has been done, and the results now are much more complete.

certain limits this is not far from the truth. However, a culvert can only operate with inlet control, in the strict sense as defined above, if its slope exceeds a certain value, usually called the critical slope, which depends on the size and roughness of the culvert, and also on the discharge. Slopes less than the critical slope are called mild, and slopes greater than critical are called steep. If a culvert is on a mild slope, frictional resistance in the barrel has a retarding influence on the discharge, an influence which increases with increasing length and roughness of the barrel.

For fairly smooth pipe, such as concrete pipe, the critical slopes are quite small in the practical design range of sizes and discharges, and are generally exceeded in highway practice. The experiments to be described have shown, however, that large corrugated-metal culverts are generally installed on mild slopes, and that barrel friction should be taken into account in determining their capacity. Neither the two sources of design information previously mentioned, nor the many culvert research publications available from American sources, gave a detailed method for analysing this type of flow. Figures for the roughness coefficient of corrugated structural plate, which is generally used for culverts exceeding 5 ft. diam., also seemed to be lacking.

It has usually been observed in practice that culverts with free outlets do not flow full, but behave as open channels over at least part of their length. Laboratory experiments with small model culverts of smooth material, however, often exhibit the phenomenon of "priming", sometimes referred to also as "siphoning", by which under certain conditions the culvert begins to flow full throughout its length. Priming may take place on mild slopes with any type of inlet, and on steep slopes with certain types of inlet, notably the hood and the bellmouth. (Fig. 1.) It has often been assumed by research workers that the same phenomena would occur in the field, but in the experiments described below no success was obtained in trying to induce the culvert to prime. The exact reason for this was uncertain, but air leakage through the joints was probably a contributing factor. Model experiments at the University of Alberta have suggested that corrugated pipe does not prime so readily as smooth pipe.

Fig. 3. Experimental culvert — inlet end

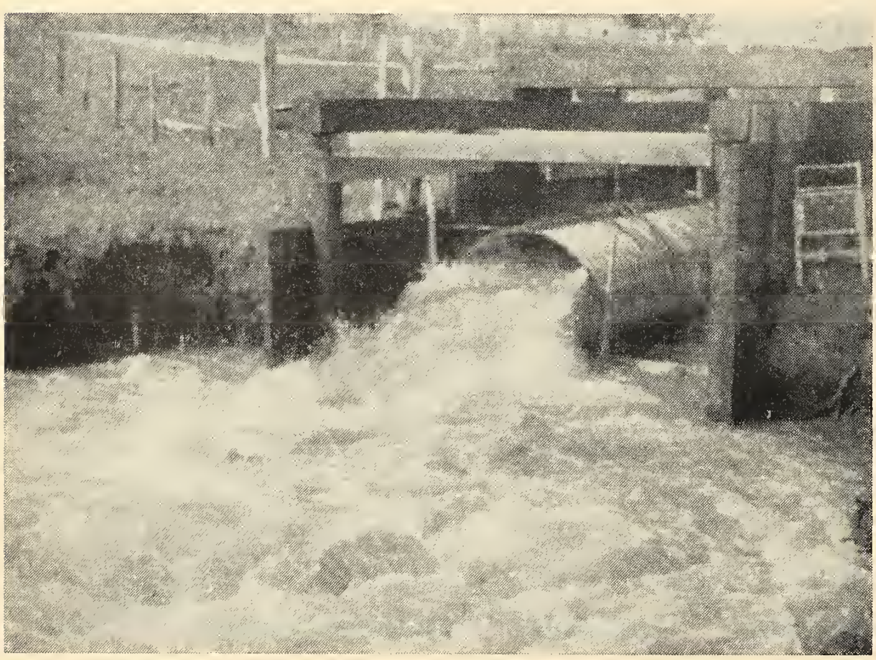


Fig. 4. Experimental culvert — outlet end. Slope 1%, Discharge 150 c.f.s.

Experimental Installation

The experimental culvert consisted of a 60 in. diam. corrugated-metal pipe of the structural plate type, i.e., a field-bolted pipe with corrugations 2 in. deep and at 6 in. pitch. It was 80 ft. long and was installed in a natural coulee which served as a spillway channel for an irrigation canal. Through the courtesy of the management of the Western Irrigation District at Strathmore, Alta., it was possible to divert water from the canal through the culvert more or less at such times and in such quantities as was convenient for the tests.

Details of the culvert are shown in Figs. 2, 3 and 4. It will be seen that it was possible to vary the slope from zero to over 3%. Piezometer taps every 10 ft., connected to a bank of manometers, enabled the approximate water surface profile, or the hydraulic grade line in the case of full flow, to be recorded. The discharge was measured by means of a sharp-crested rectangular weir located a short distance downstream of the culvert. Headwater and tailwater depths were read by means of gauge boards attached to the inlet and the outlet of the culvert.

Test Program

The test program carried out in 1960 was not quite as extensive as had originally been intended, since the installation was not completed until late in the summer, and the irrigation water was shut off a few weeks later. However, about 40 different tests were made at various slopes, at headwater depths up to more than 8 ft., and with four types of inlet — square projecting, bevel projecting, bevel flush, and hood. Some photographs of the tests are shown in Figs. 4, 5 and 6.

In addition to tests on the experimental culvert, a few readings were obtained on two 84 in. diameter culverts of similar type, located on the same watercourse some distance downstream of the experimental site.

A further test program may be carried out this summer.

Test Results

All of the test results for the 60 in. diameter culvert have been plotted on Fig. 7 in terms of headwater depth (H) against discharge (Q). In the diagram as reproduced, no attempt has been made to distinguish between the various slopes and inlets, since the influence of the several factors is not easily detected on this diagram. Also shown on the diagram are two lines representing the data given by the manufacturers' charts and by the Bureau of Public Roads nomograph. It will be noted that practically all the points lie above the two lines, i.e., they indicate higher headwater depths for a given discharge, although, except at the higher discharges, the deviation from the Bureau of Public Roads figures is quite small.

Fig. 5. Experimental culvert — flow at inlet

Fig. 6. Experimental culvert — flow inside pipe. Slope 3%, Discharge 80 c.f.s., pipe half full

In most of the tests a free water surface prevailed throughout the culvert. In some of the tests with high discharges and small slopes, the culvert ran full at the inlet and for some distance downstream, but with a free surface towards the outlet end. Analysis has shown that this was not a priming phenomenon, but can be explained by open channel theory. Velocities were sub-critical in most of the tests, but around critical in a few. The depth of flow at the beginning of the outlet bevel (Fig. 2) was always very close to the critical depth, except in a few of the tests at low discharges on a 3% slope, when the tailwater depth exceeded the critical depth.

Fig. 8 shows a non-dimensional plot of the test results for the square projecting and bevel flush inlets, on slopes of 1% and higher, together with a curve published by Schiller[1] as a result of tests on 5 in. diameter smooth models with the same types of inlet. (Both model and field tests showed practically no difference in the performance of these two inlets.) It is felt that the close agreement between the field results and Schiller's gives a good check on the field discharge measurements. At H/D ratios below 1.0, and on slopes of 1% or higher, the capacity of the large culvert is not affected noticeably by friction, (as will be seen later by examining the design charts, Figs. 12 and 13), so that a non-dimensional plot should show very close agreement with models. The Bureau of Public Roads curve shown on Fig. 7 is practically identical with Schiller's when plotted non-dimensionally.

Analysis of Results

Where approximately uniform flow occurred throughout the pipe, the roughness coefficient, i.e., Manning's "n", was calculated directly from the observed depth of flow and the discharge. Where non-uniform flow occurred, trial backwater calculations were made with different values of n, until the calculated and observed water surface profiles showed close agreement. Most of the n values obtained were in the range from 0.030 to 0.040, with an average from all tests of 0.035. In view of the scatter, perhaps not too much weight should be attached to the average value, but the true value is thought to be almost certainly in excess of 0.030. It is possible, however, that measurements at uniform depth in a longer pipe would give somewhat lower values than these tests. Since recent experiments[2] have established $n=0.024$ for large standard corrugated pipe with corrugations only $\frac{1}{2}$ in. deep, the test results are not too surprising.

If Manning's n is known, and the discharge given, a step backwater calculation enables the water surface profile to be drawn for any culvert on a mild slope. If the outlet is "free", i.e., if the tailwater depth is less than critical depth for the pipe, the

water surface must pass through critical depth at the outlet. The critical depth can be calculated for the given discharge (tables to facilitate this being available for circular pipe), and the step calculations started at the outlet, and continued until the calculated profile reaches the inlet end. If the calculated profile hits the roof of the culvert downstream of the inlet, the culvert must run full upstream of this point; the hydraulic gradient for full flow can then be calculated and produced until it reaches the inlet (Fig. 9.)

By this means the elevation, either of the water surface or of the hydraulic grade line just downstream of the inlet, is obtained. To obtain the elevation of the headwater pond, which is the desired figure, a gap still has to be bridged. In passing from the headpond to the culvert barrel, the water converts potential energy (or static head) to kinetic energy (or velocity head), and loses energy due to turbulence caused by the shape of the inlet. The difference in elevation between the headpond and the water surface or hydraulic grade line inside the pipe, which we shall call the "entrance drawdown", therefore represents kinetic energy + energy loss (Fig. 9). In order to complete the calculation it is necessary to have a reliable means of estimating the entrance drawdown, and recourse must be made to experimental data.

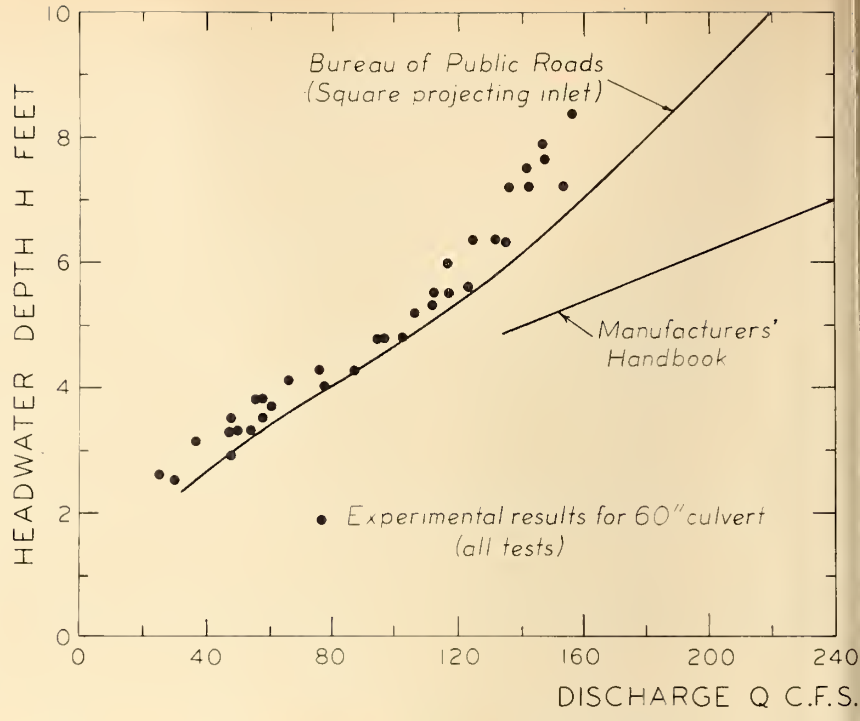
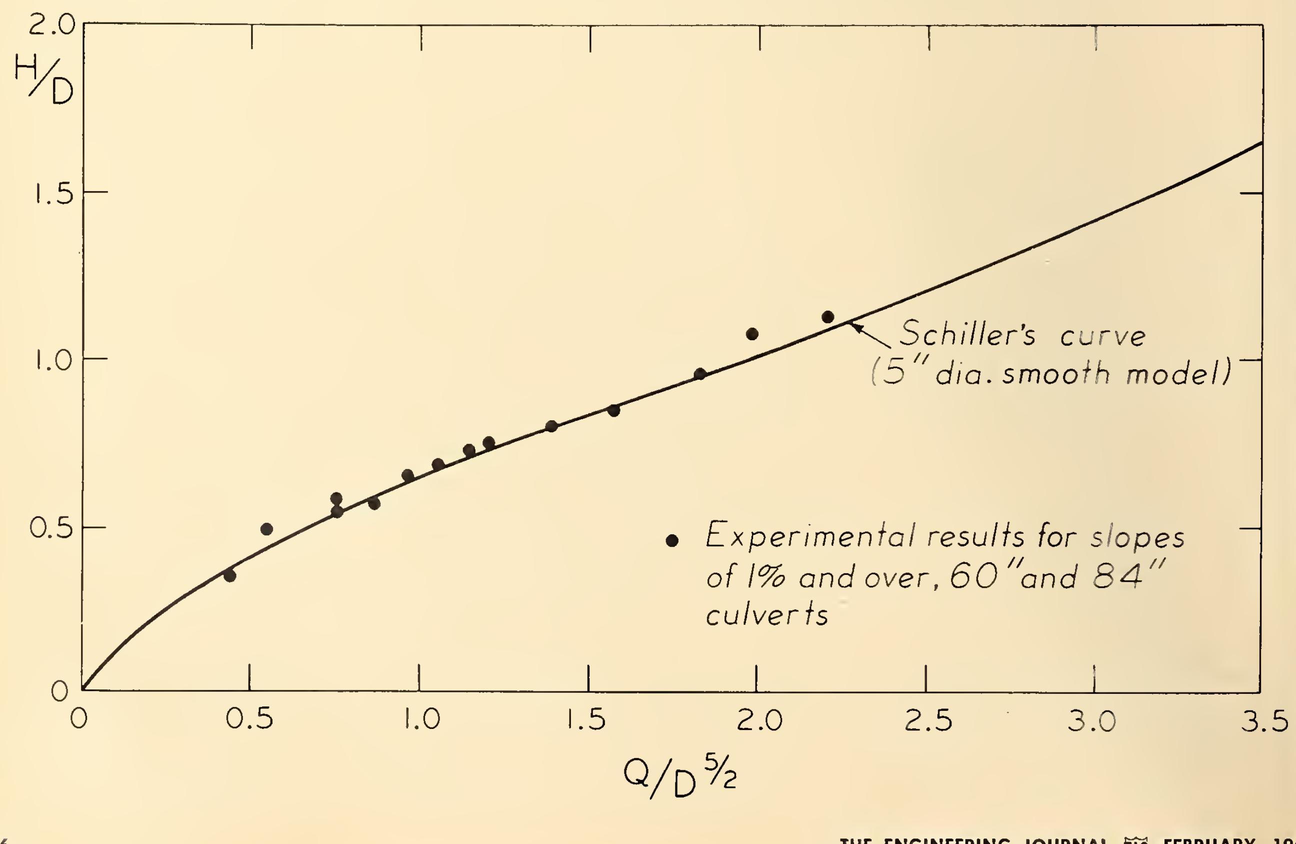


Fig. 7. Experimental results compared with design data for 60 in. C.M. culvert

In attempting to analyse the test results, the writer soon concluded that it was futile to try to separate the energy conversion and the energy loss, as most previous investigators have tried to do. (One reason for this is that the kinetic energy cannot be taken simply as equal to $V^2/2g$, but should include a "kinetic energy correction factor", which depends on the velocity distribution, which was unknown.) The writer felt that the only practical course was to express the entrance drawdown in terms of the

Fig. 8. Experimental results compared with Schiller's model results (square projecting or bevel flush inlet)



velocity head just downstream of the inlet, since the latter quantity would be known in any particular case from the backwater calculation. If we call the entrance drawn h_e^1 (since other writers have used h_e for the entrance loss), we get the equation

h_e^1 = K.E. + energy loss = $kV_e^2/2g$

where k is a numerical factor, which we shall call the entrance drawdown coefficient.

Experimental evidence shows that k is not a constant for any given shape of inlet, but increases as the headwater depth rises, at least within limits. Fig. 10 shows the values of k calculated from the tests, plotted against $Q/D^{5/2}$. Although there is considerable scatter, the points suggest that k rises from 1.0 at zero discharge to a limiting value at high discharge, which for the square projecting inlet seems to be about 2.2. If the entrance loss coefficient for full flow (for this type of inlet) is taken as 0.9, as found by several investigators, the corresponding value of the kinetic energy correction factor would be 1.3, which is believed to be reasonable for corrugated pipe.

It is recognized that the plotting of k against $Q/D^{5/2}$ has little theoretical justification, and that the data presented on this point are very limited. More experimental and theoretical work is required to give a sound basis for predicting k. However, the pattern of flow at a culvert inlet, as Fig. 5 demonstrates, is extremely complex, and it is very doubtful if a rigorously correct theory can be developed, taking into account the three-dimensional nature of the flow, its curvature, pressure distribution, and velocity distribution. The use of $Q/D^{5/2}$ as parameter enables the calculation of headwater depth for a known discharge to be completed, by taking a value of k from Fig. 10.

Preparation of Design Charts

Based on the method of analysis outlined above, design charts have been prepared for a 60 in. diameter structural plate culvert with a square projecting inlet, on slopes of 0, 1%, 2%, and 3% for lengths of 70 ft., 150 ft., and 300 ft., and at headwater depths of up to 15 ft. A sample calculation is given in Fig. 11, and the charts are reproduced as Figs. 12 and 13. The experimental results, where applicable, fall almost exactly on the curves for the 70 ft. length.

It may be noted that in the sample calculation, Manning's n was taken as 0.035, the average figure from all the tests. The writer would not attempt to assert that this is necessarily the true value for the pipe in ques-

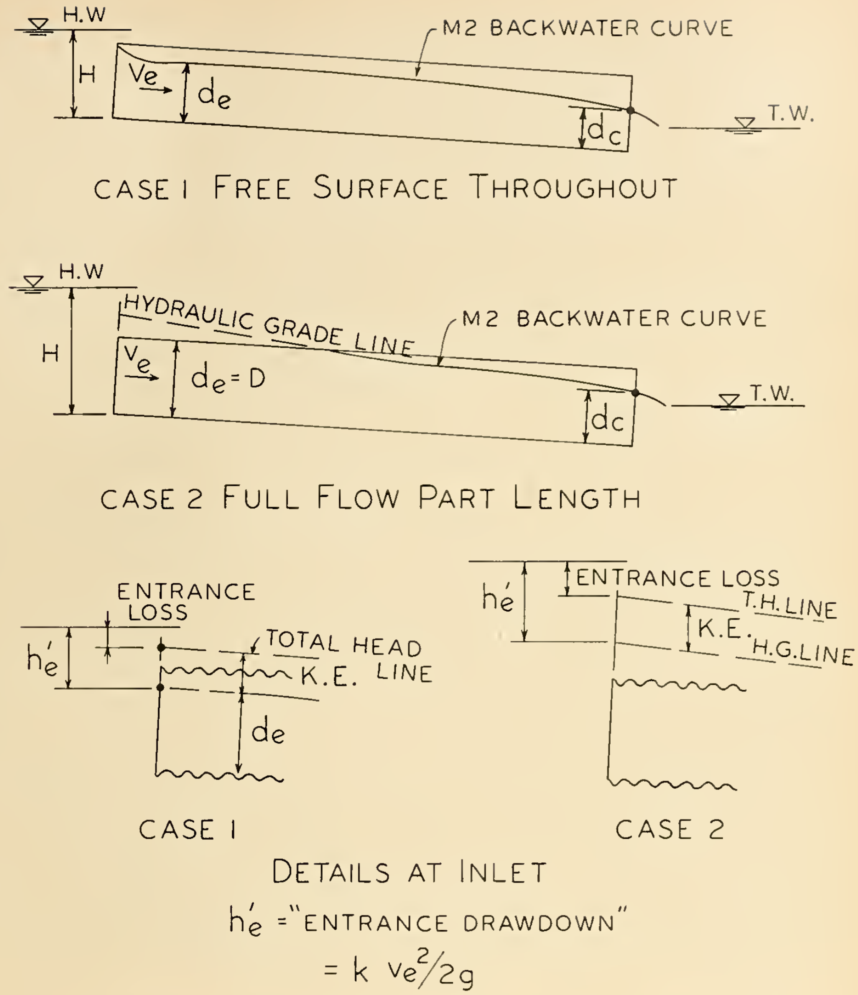
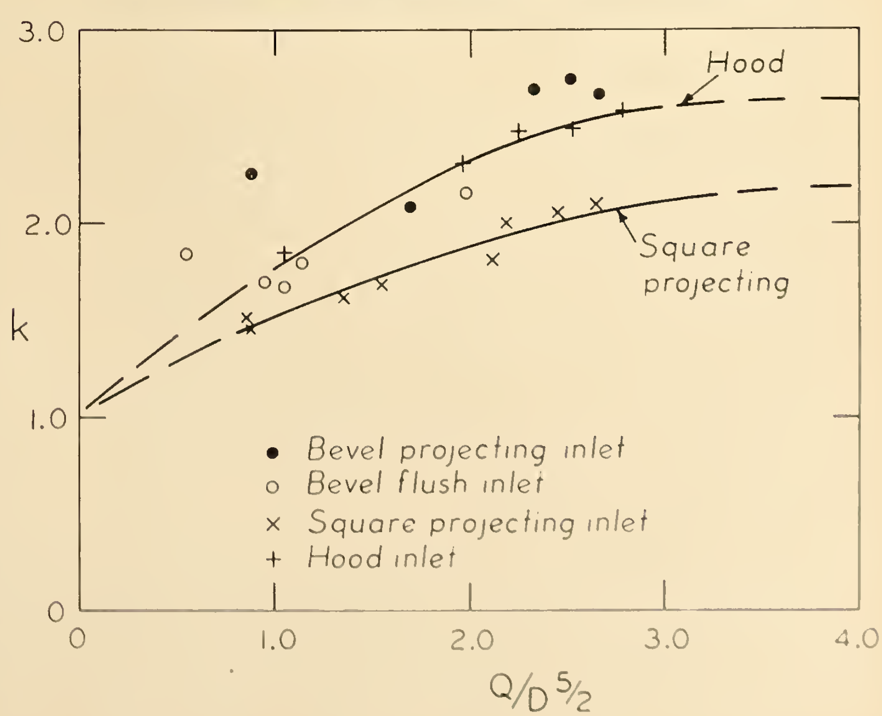


Fig. 9. Operation of culvert with free outlet on mild slope

Fig. 10. Experimental values of entrance drawdown coefficient k



tion, since the field tests were not set up to measure n accurately, but to determine discharges. The use of a value of 0.035 in the method of calculation presented here, does however give answers which agree with experiment, and is felt to be justified on that account.

It is hoped to produce ultimately similar charts for all sizes of pipe and pipe-arch in common use. It is believed that these charts will be more accurate and more convenient to use than anything which has been published previously. They will provide not only a means of designing large culverts with assurance, but also of closely estimating stream flood discharges from observations of culvert water levels.

Acknowledgements

The author wishes to thank the Alberta Department of Highways and the Research Council of Alberta for permission to publish this paper. He also wishes to thank Dr. T. Blench, Professor of Hydraulics at the University of Alberta, for his helpful suggestions.

Fig. 11. Sample Calculation Showing Method of Deriving Design Charts

Given: Dia. $D = 5'$, Discharge $Q = 120$ c.f.s., Manning's $n = 0.035$
Invert slope $S_0 = 1\% = 0.010$

Then $D^{5/2} = 56$ and $Q/D^{5/2} = 2.14$.

Assume K.E. correction factor $\alpha = 1.3$.

Critical depth ratio, from tables, $= 0.625$.

Corrected critical depth $d_c = 0.625 \times 5 \times \sqrt{1.3} = 3.4'$.

By Manning's formula, friction slope $Sf = \left(\frac{Qn}{1.49AR^{2/3}}\right)^2 = 7.95/(AR^{2/3})^2$.

Energy of flow, Ef = depth + velocity head $= d + \frac{\alpha V^2}{2g}$.

$$\alpha V^2/2g = 1.3Q^2/2gA^2 = 291/A^2. \qquad \Delta L = \frac{\Delta Ef}{Sf - S_0}.$$

Backwater Calculation:

d	A	R	$R^{2/3}$	$\alpha V^2/2g$	Ef	ΔEf	Sf	$Sf - S_0$	ΔL	L
3.4	14.2	1.46	1.29	1.44	4.84					
3.8	16.0	1.51	1.32	1.14	4.94	0.10	0.0178	0.0078	13	13
4.1	17.2	1.52	1.32	0.98	5.08	0.14	0.0154	0.0054	26	39
4.4	18.3	1.50	1.31	0.87	5.27	0.19	0.0138	0.0038	50	89
4.6	18.9	1.46	1.29	0.81	5.41	0.14	0.0134	0.0034	41	130
4.8	19.4	1.41	1.26	0.77	5.57	0.16	0.0133	0.0033	48	178
5.0	19.6	1.25	1.16	0.75	5.75	0.18	0.0153	0.0053	34	212

From Fig. 10, entrance drawdown coefficient $k = 1.9$.

Culvert Length $L = 70'$: $de = 4.3'$ $\qquad Ve^2/2g = 0.69'$
Headwater depth $H = 4.3 + 1.9 \times 0.69 = 5.6'$

$L = 150'$ $\qquad de = 4.7'$, $\qquad Ve^2/2g = 0.61$
$H = 4.7 + 1.9 \times 0.61 = 5.9'$

$L = 300'$ Length flowing full, $lf = 300' - 212' = 88'$
$lf(Sf - S_0) = 88 \times 0.0053 = 0.47'$ $\qquad Ve^2/2g = 0.58'$
$H = 5.47' + 1.9 \times 0.58 = 6.6'$.

References

1. **Tests on Circular-Pipe-Culvert Inlets** by R. E. Schiller, Highway Research Board Bulletin 126, 1956.
2. **Friction Factors in Corrugated Metal Pipe** by Webster and Metcalf, Journal of the Hydraulics Division, A.S.C.E., Sept. 1959.

Fig. 12. Sample design charts for 60 in. culvert, slopes 0 and 1%, n=0.035

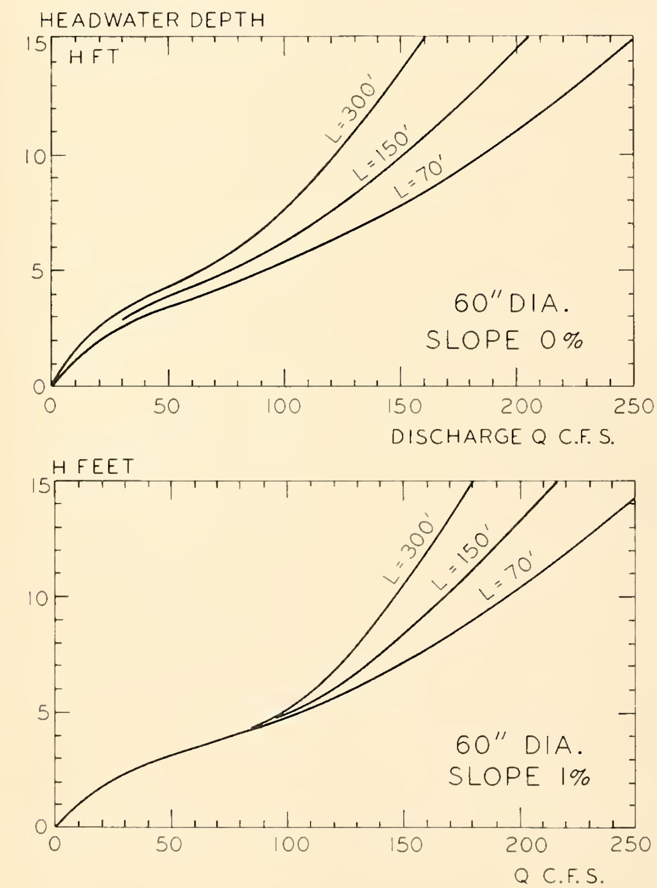
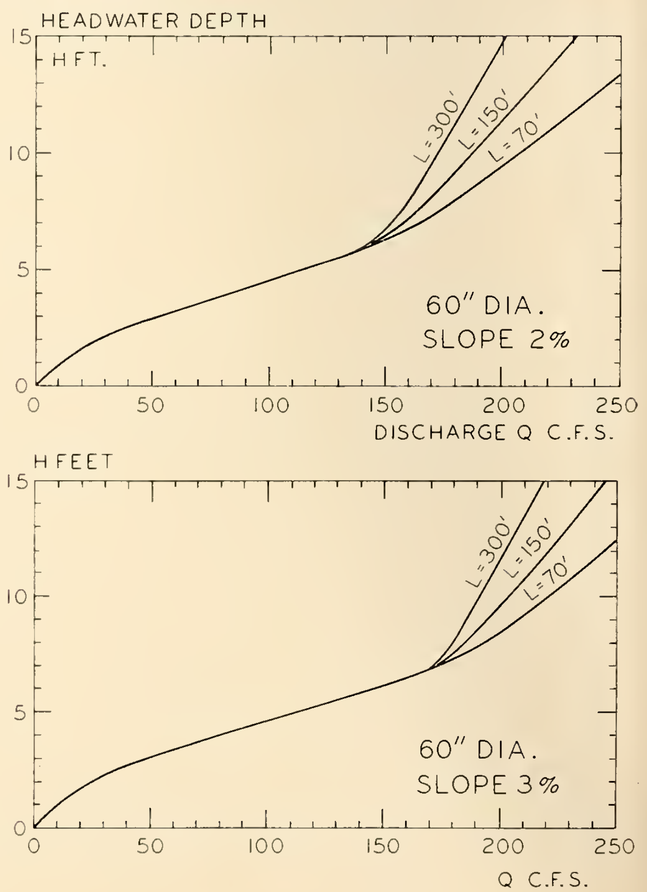


Fig. 13. Sample design charts for 60 in. culvert, slopes 2% and 3%, n=0.035



THE FACTORS INVOLVED IN THE DESIGN OF A CANADIAN GANGSAW

E. N. Parker, M.E.I.C.

Presented at the 75th E.I.C. Annual General Meeting, Vancouver, May 1961.

THREE basic types of saws are used for producing lumber in Canada, the circular, the band and the gang or vertical frame saw. Each saw has its place in the sawmill but it would appear that the use of the first two types, in the past, has overshadowed the third in most mills.

The gangsaw, however, in recent years has become more popular, due to the fact that it usually requires less labour to saw a given volume of logs, cuts a smaller kerf and more accurately dimensioned lumber. Its major disadvantage is that if used for pri-

mary breakdown, it does not permit turning of the log to get the best grade yield. These points will be discussed in detail in their place.

Vertical frame saws of a crude variety, driven by hand or water power have been in use for centuries. The modern variety of saw, now powered by electricity, internal combustion or still occasionally by steam engine, was first built in Great Britain more than 100 years ago. Its development lagged there and the German, Scandinavian and other continental countries advanced their designs and took over much of the market. American designed saws have been sold for many years and more recently Canadian designed machines have been available.

The European market, for which the Continental gangsaws were originally manufactured, operates in a different way from its usual North American counterpart. Most timber available for cutting is second growth of relatively small size by our Western standards. Due to a limited supply, strict government regulations regarding the amount of cutting and waste tolerated are enforced.

The logs are sorted carefully in a pond for size and type before cutting and in general are fed to the gangsaw, as logs, in batches of similar dimension and material. By adjusting the blade spacing to suit, before starting, the dimensions of the lumber sawn can be tailored to the size of log being used during the shift.

Sawmills in Europe, as on this continent, exist in all sizes, from the very smallest, with just one simple saw, to the very largest, containing many saws and employing hundreds, in well constructed permanent buildings.

In North America and in particular, in Canada, a wide variety of timber is found. There is still a large amount of virgin growth available, although it is receding to remoter areas, year by year, with the result that second and subsequent generation timber now is being utilized in many parts of the country.

The Canadian sawmill industry and also the American, differs in one marked way from the European, in that there is very little government control of the milling process. The timber cutting rights, in many instances, have been obtained from the provincial governments and the usual controls are those ensuring sustained yield forestry, which covers selective cutting and reforestation.

North American sawmill practice differs from the European also in that there is usually very little sorting of the timber as to size or type before sawing. Unless the mill has a relatively small tract or is cutting on a sustained yield basis, maximum production is the goal. The logs are brought into the mill in any range of sizes that may exist in the pond or storage yard. The more widely separated types of timber are normally segregated and sawn independently in most mills, however.

Two types of gangsaw milling are popular in North America. There is some cutting of timber directly from logs, as in European practice but much more is processed as cants, which are square or rectangular timbers. These cants are produced, either directly from the smaller logs by slabbing them on two sides in a two saw gangsaw or on two or four sides in a conventional circular or band headsaw. Cants may also be available as the residue from cutting a large log to secure the maximum amount of high grade lumber.

One of the outstanding features of North American sawmilling, from the beginning, has been its migratory character. Mills would operate in one region, until the virgin timber was exhausted, then move to another uncut district. Transportation of the logs had much to do with the practice, with the result that it was only on tidewater or on the great rivers where large mills still continue to operate.

The tree farm system is helping to change this situation today with the result that more permanent mill installations should develop.

A great number of the migratory small mills still exist, however, and they will probably continue to carry on for some time. The simplest mill for this type of operation is equipped with a circular head saw and a carriage, driven by a diesel or gasoline engine, which may all be mounted on a heavy trailer ready to be moved every few months. At the other end of the scale is the operater with a semi-permanent complete mill installation, including both a circular or band head saw and a gangsaw housed in a wood or steel framed, galvanized iron or aluminum sheathed building. The machinery is supported on timber as much as possible but where necessary, on reinforced concrete. These are kept to the minimum, as all foundations are abandoned when the mill is moved.

All sawmills are operated to make money for their owners. To do this the mills must be operated to yield the maximum amount of lumber, of the highest possible quality from the timber available, with the minimum labor force. In a gangsaw equipped sawmill, each of these three conditions may be satisfied.

With the elementary circular saw, a wide kerf and some uncertainty of the thickness of lumber cut results. The bandsaw cuts a narrow kerf but thickness of the lumber is still not too accurate. In each case the saw carriage must be moved through a complete return travel cycle for each plank cut.

The gangsaw, however, cuts a narrow kerf and very accurate lumber thickness with the result that the amount left for planing can be reduced to a minimum. This gives an overcut above the board feet of lumber available from the timber sizes given in the standard tables.

The price paid for lumber on the basis of quality has a bearing on the method of sawing though, so that even if the gangsaw were large enough to accommodate the whole log, it might not be the most economic way of cutting it.

With the larger logs, the outer portion can be sawn to give higher grade lumber if the log is rotated between cuts. This cutting is usually done by a circular or band head saw. A typical cross-section of a fir log noting the cuts is shown in Fig. 1. To cut it in this way, the sawyer can control the thickness either manually or automatically and also rotate the log between cuts. The result is a log divided up into individual heavy planks and cants. These are then passed through a gangsaw to reduce them to accurately sized lumber with the minimum of waste. If the gangsaw opening is large enough, the cants or planks may be stacked side by side or on top of one another to saw the maximum volume allowed by the saw opening, which ensures a high rate of cut. This overall method of cutting will result in a higher return than if the log had been directly passed through the gangsaw, even though more sawdust waste is incurred in the cuts made by the thicker circular saw.

From this it can be seen that the operator of a small mill using a circular or band head saw for all his cutting can adapt a gangsaw into his production line to improve the quality and quantity of output.

Gangsaws are made in a variety of sizes. The large permanent mills use saws with openings 3 to 4 ft. wide with heights of up to about 3 ft. These machines are very heavy, with weights of 70,000 lb. or more and require massive foundations. The driving motors may be as large as 400 h.p.

The smaller migratory mills use saws with openings capable of taking logs or cants about 2 ft. wide with heights of up to the same amount. The saws are lighter and for ease of transportation preferably of a con-

struction which allows them to be shipped in one piece. This enables the machine to be set up with the minimum of skilled labor and time. Weights of these saws vary with size, the usual range being from 6,000 to 16,000 lb.

If the mill is used for sawing logs directly or a combination of logs and cants, the square opening saw is usually chosen. Where cants alone are to be sawn, the rectangular opening saw may be selected, the height being one half to three quarters that of the width as the cants are usually of that shape. When equipped with twin feed rolls, the square opening saw may be preferred as the cants can be stacked to fill the opening.

To achieve a continuous high output is the goal of most sawmill operators. This operation of a mill under continuous production pressure is one of the factors which has the greatest influence on the design of a saw for Canadian conditions. There is little time for shutdown, except on weekends, as every hour down during the production period can mean a loss of revenue. Most mills run on a single eight hour shift but others maintain a two or even a three shift operation.

Preventive maintenance and good lubrication can do much towards keeping the saw running properly during the working day. The designer, however, has to do his best to make the saw operate under conditions where neither of these items is given the attention it deserves.

In many mills the gangsaw and other equipment is operated continuously for four hours, is shut down for the half hour lunch break, then is run steadily for the remaining four hours of the shift. In the half hour break, the maintenance man and helper must change most of the saws for resharpened ones and grease and oil all the equipment in the mill as best they can. There is little or no opportunity to carry this out while the mill is running, due to the movement of the timber through all parts of the mill. Some mills have made a practice of shutting down after two hours of operation for additional lubrication, which pays off in reduced wear and longer life of the rubbing parts.

Where sliding bearing surfaces are used, reservoir grease fittings or oil reservoirs and pumps are supplied to extend the supply of lubricant. The use of rolling bearings, which can be packed with lubricant for a lengthy period of operation, has also spread. These bearings must be well sealed to prevent the entry of sawdust and preferably be equipped with housings which allow the grease added by fittings to pass through the bearing and out the seals, thereby flushing the dust away.

For this reason too, attention must be given to the lubricants recommended, especially on open rubbing surfaces. An oil which becomes gummy with use tends to pick up the sawdust and cause blockage of the lubrication grooves and passages. A free flowing oil helps to wash away deposits on flat vertical guide surfaces. Different winter and summer grades of the oil may be necessary to ensure fluidity at all times.

Before describing the various features of gangsaw design it would be as well to examine the usual parts and their functions in a typical saw. These and the remarks that follow about design refer principally to the medium and smaller size Canadian built semi-portable saw. Typical types are illustrated in Figs. 2, 3.

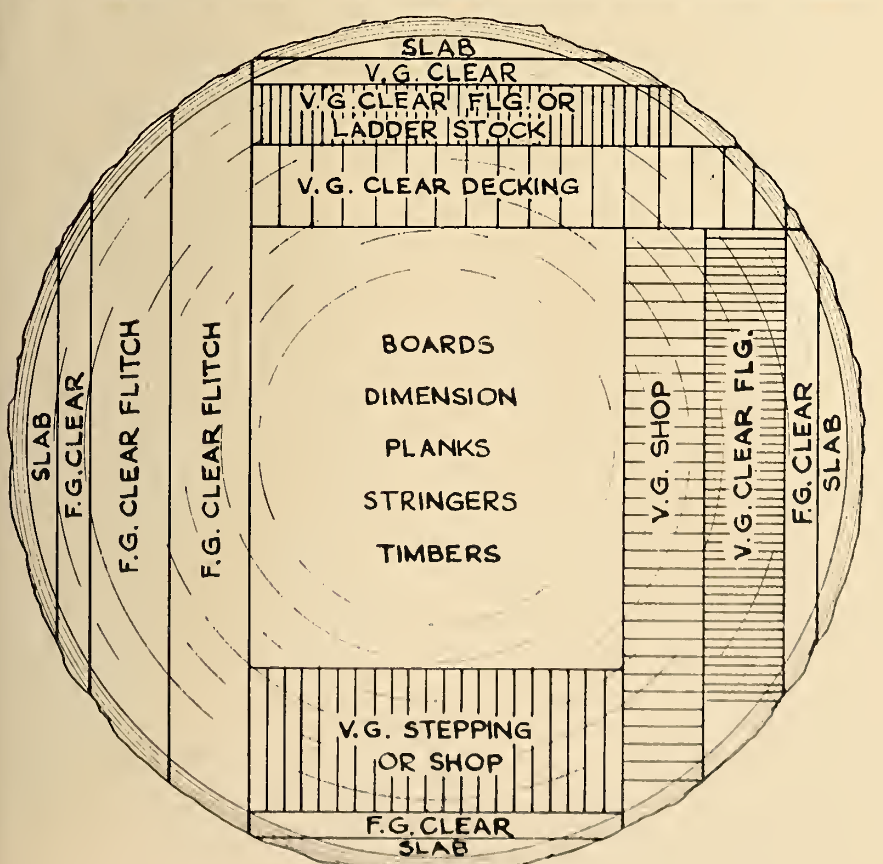
The individual saws are mounted in a vertical frame. This frame moves up and down on shoes, attached to the upper and lower girder ends, which slide in adjustable guides.

Connecting rods are attached to the ends of the top or bottom girder, depending on the designer's preference, and to cranks on the main shaft. The cranks may be part of a flywheel on each side of the saw or separate units incorporating balance weights, in which case a separate flywheel is used on the shaft. Another variation is found on some saws which have a single connecting rod fastened to the centre of the lower girder.

The base of the saw carries the main shaft bearings and side frames support most of the other parts. A top spreader placed between the side frames sometimes serves as a mount for the lubricator or feed drive but must also be strong enough to take the whole weight of the saw, when it is lifted by a crane.

The timber is brought up to the saw on live chains or rolls but to force it through the saws, power driven feed rolls are incorporated on the infeed and outfeed sides of the saw. Two rolls are fitted on each side, the lower ones being fixed in position and the upper ones mounted on a frame or gate, which can be raised or lowered by a power cylinder or rack. The gate is usually pivotted on one side so that it may be swung outward to give clear access for changing the saws. The upper rolls are normally driven but on saws designed to be used for cants only, this feature is sometimes omitted. On certain models the top feed rolls may be split into two sections, which are operated independently, to allow two or more cants or logs of different size to be

Fig. 1. Diagram of a typical fir log illustrating where the various products originate.



sawn at the time. This is illustrated in Fig. 4.

The feed mechanism can be driven from the main shaft of the machine through some type of variable speed drive or it may be powered by a separate electric, hydraulic or air motor. Some means of reversing the rolls is usually supplied, so that jams may be cleared quickly.

The feed speed is governed by the size of timber being sawn, the larger the size, the slower the feed. In sawing lumber by a gangsaw it must be realized that if the feed is made continuous and the blades are vertical, during the upstroke the back of the teeth would rub on the advancing wood. This may be overcome by tilting the saw blade slightly, with the top leading into incoming cant or log, giving the blade what is known as overhang. However, for every speed there is a most suitable overhang and if the amount of feed per stroke is changed appreciably, the overhang setting should vary with it. A manual setting of this in the frame can be quite acceptable, if the timber is graded carefully for size, as the overhang can be set for the size being sawn during a particular shift.

One way of avoiding this problem is to use an intermittent feed, advancing the timber on the cutting stroke only. This works most satisfactorily with the smaller logs or cants, which do not have too much weight to start and stop every revolution of the saw. A certain amount of overhang is used with this system too.

Where greater production is desired from the saw and the size of timber may vary considerably, another solution is to use with continuous feed, an adjustable overhang system, which allows the upper or lower sash guides to be advanced or retarded without shutting down the saw. When this is linked with the feed speed control it is known as automatic overhang, as the overhang is always correctly co-ordinated with the feed speed.

High production rates can also be achieved with continuous feed by the use of an oscillating bearing between the sash girder trunnion and the guide shoe. This is designed to withdraw the sash and saws at a faster speed than the timber advances during the up stroke. It is used in conjunction with a certain amount of fixed overhang and has proven to be one of the least complicated and most satisfactory ways of overcoming this problem, for a wide range of feed speeds.

The first method, using fixed overhang, allows timber of mixed sizes to be sawn up to about ¾ in. feed per stroke with one setting, the second, using intermittent feed, up to about 1 in. per stroke and the last two, adjustable overhang or oscillation, up to 1½ in. per stroke. These values may be exceeded slightly in some cases but usually at a cost in factors such as tooth wear and quality of lumber.

Power for the main shaft drive of the gangsaw is usually supplied by an electric motor or diesel engine. Flat or vee belts are used between the power source and counter shaft or saw to reduce the speed, as necessary, to the 250 to 350 r.p.m. operating speed of the saw.

Before commencing the design of a gangsaw, as with any machine designed for quantity production, certain ground rules must be established in the form of a specification. No one saw can supply all potential customer's demands and therefore the market for which the saw is intended must first be settled. The size and type of timber capable of being sawn and the output desired are basic considerations.

Market surveys conducted by the sales department will determine the most advantageous sizes with a target cost price. Once this has been approved by management a reasonably firm specification can be written. This may even include a certain number of features thought desirable by the sales or engineering departments, which will later have to be abandoned due to high cost or manufacturing impractibility. Design and development budgets can be roughed out from this specification and when approved, the work may be started.

The design of the saw generally starts with the saw frame. The largest loads imposed on the girders and tubular columns arise from the saw tensioning. This tension is applied to the saw hangers by cams and wedges or by a hydraulic tensioning system. Some attempts have been made to use screw tighteners but they have usually proved to be too slow in operation or too bulky. Most saws are designed to cut down to 1 in. lumber, which leaves little room for a device that must load each saw with a tension of 6,000 to 8,000 lb. or more. The frame must be designed to resist these loads from a full set of saws plus the dynamic loads arising from the reciprocating and sawing actions.

The human factor enters into this situation too. Due to the fact that the saws heat when working, elongation takes place reducing the tension. This may allow the blade to flex somewhat causing the sawing of uneven lumber. The sawyer attempts to compensate for this and with cams is tempted to elongate the cam wrench

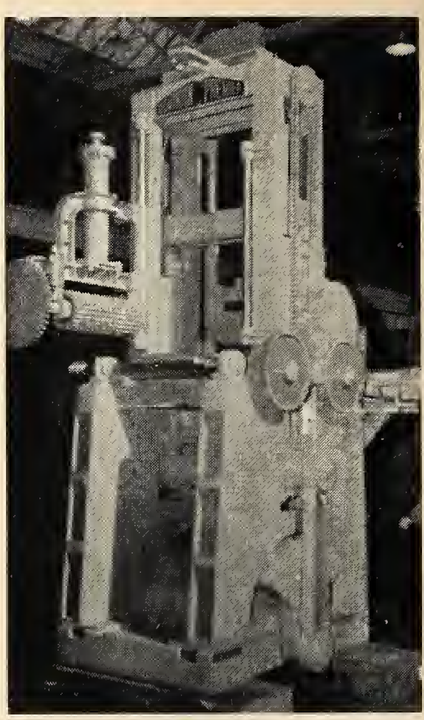


Fig. 2.

with a length of pipe, to introduce more tension. The proper alternative is to stop the saw and retighten the blades after they have become warm.

The hydraulic loading device, which is used to help overcome this problem, is attached to the top of the upper girder of the frame. Interconnected small individual cylinders with pistons, at about 1 in. centres, support one end of the wedge through the saw hangers. The overall pumped-in pressure equalizes the load on all saws, keeping a high average pressure, as in normal sawing all blades in the frame may not be used to the same degree.

These devices have met with a mixed reception and are relatively expensive. Many mills, which are known to have started out with or tried these on their gangsaws, have reverted to the cam type of tighteners. If care is taken to centre the wedges and hangers on the buttons each time and slope the hangers to the saw connection near the spacers, the device can operate satisfactorily over a long period. When the pistons are loaded eccentrically, however, uneven wear takes place in the cylinders resulting in unsatisfactory operation. The deflection of the girder under load, causing a similar deflection in the tensioner body also appears to contribute to the wear.

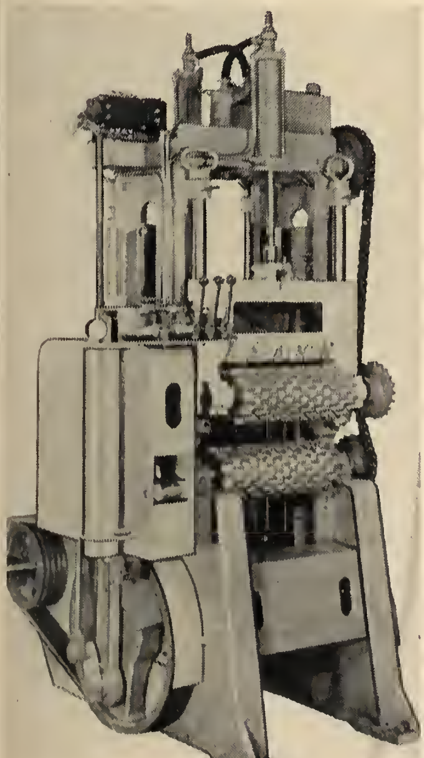
Cooling of the blades by water spray or water mist has also been used to combat the problem of blade expansion due to heat. The designer must weigh up all these load factors and still produce girders and columns

which are as light as possible. Girders of rolled steel combined with castings or forgings into weldments or high strength steel castings are the usual alternatives. The use of material with good ductility is essential so that under extreme overloads the components will bend rather than fracture abruptly. Saw hangers are normally high strength steel drop forgings or are made of saw blade steel.

The guide shoes attached to the ends of the upper and lower girders usually work in cast iron ways. The ways on one side are fixed and the other side free, to allow for expansion. The fixed ways may be flat with adjustment for flat shoe faces bearing on each side or they may have a Vee section. Oil grooves are cut in the ways and supplied with oil from a central lubrication source. Slotted holes for bolts or studs, in the ways, allow for wear adjustment or the setting of overhang. Backup screws are used to lock the adjustment.

The shoes are usually bronze faced although various plastics have proven successful. Some of these can be lubricated with water if desired, which is impractical for winter operation in Canada. So called dryslip materials have been tried experimentally but did not prove satisfactory without lubrication. The thrust load on the shoes at the connecting rod end proved too great, although the material on the shoes at the opposite end of the frame seemed to work acceptably unlubricated. The material also acts as an insulator and does not carry away the heat generated by the friction.

Fig. 3.



Thin, ribbon like strips of one of the nylon family of plastics impregnated with molybdenum disulphide appeared to work satisfactorily without lubricants, with little wear when tested, which did allow the heat to pass through to the metal mounting base. The conclusion was reached, however, that the time tested bronze surface, properly lubricated, was the least likely to give trouble as the average operator is familiar with its characteristics.

The connecting rods used on these machines are similar to those on any reciprocating equipment. Some are attached to the ends of the top girder and other saws have them fastened to the bottom girder.

The choice of location is a result of weighing up several factors. If attached to the top, the rod is longer and heavier but with less angularity, the side thrust is reduced on the guides. The rod connected to the bottom of the frame is shorter, sturdier and lighter and with the usual proportions of machine, the resultant difference in side load is not too great. With the oscillating type of machine it is desirable that the rod be connected to the bottom girder.

The connecting rods are made from castings, forgings, box shaped weldments and machined to an I section from thick steel plate. From the reliability standpoint, the forging or plate construction has proved very successful for quantity production. Weldments and castings in a part of this nature, subject to reversals of stress and fatigue loads, require careful control of manufacture and rigorous inspection to ensure reliability and therefore may be more expensive.

The top bearing of the rod with its limited movement has normally been designed with a plain bronze bushing, although self aligning rolling bearings may be used. The deflection of the girder with the consequent change of angle of the journals on its ends, requires some provision for this slight angular movement. Ratings of rolling bearings for the limited rotational swing are low, resulting in a large outside diameter or width in comparison with the journal size.

The lower bearing, on the crankpin, is almost always a self aligning rolling bearing as are the main shaft bearings. These must be very conservatively rated as the designer never knows the type of service the saw will encounter and changing main bearings can be costly and time consuming. Unfortunately too, these bearings do not always give an indication of wear and occasionally failure may be rather abrupt. Mill operators would be well advised to keep a log on their rolling bearings and replace them at recommended intervals.

Crank pins and main shafts are best made of high strength alloy steels, properly heat treated, as the savings possible in the size of bearings and other parts are worth while. High strength cast iron flywheels and cast steel crank webs have worked out well in service and are economical where balance weight is desired. The balancing of the reciprocating forces in the saw presents a problem. Unless elaborate counter-balance measures were incorporated, it would be impossible to eliminate the vibration. The number of saws in the frame varies, so that an average figure must be used in calculations. Individual preferences of the designers result in different proportions of out of balance in the horizontal and vertical planes, although generally the amount in each plane is made about equal.

The saw frame may be made of castings or weldments. Cast iron has excellent vibration damping properties but unless used in massive sections can be damaged in transport or severe service. Structural steel weldments, sometimes incorporating steel castings, can be made into a rugged lightweight frame, capable of taking much punishment, although the damping properties are lower. Adequate stress relieving of the frames is necessary to prevent movement after machining. This also applies to many of the steel castings, where movement cannot be tolerated, as they may not have been thoroughly annealed or normalized at the foundry, due to production pressure.

The feed mechanism on the saw is usually roller chain driven. Rolls are fluted, solid flutes being used where all cant operation is normal, interrupted flutes with comb teeth cleaning where logs are used. A combination roll is popular which has provision for driving logs in the centre and cants at the outsides. Rolls are normally steel castings for wear resistance, turned on the outside diameter of the flutes. After wear they are often built up with hard facing welding rod, which must be ground to a true diameter to ensure a straight feed.

The upper rolls are held against or retracted from the timber by cylinder pressure, which may be pneumatically or hydraulically operated. Both methods have their advantages and disadvantages. The air cylinder has more

cushioning effect, especially for log operation, which may present a very uneven surface. It requires a separate source of supply for the air but most mills have air compressors to power cylinders in other parts of the building. Hydraulic cylinders with relief valves to limit the roll pressure, together with hydraulic motors for the feed drive, may be powered by a pump coupled to the main shaft of the saw. Servicing of the hydraulic components may be more difficult in outlying areas but today with their use on all types of contractor's equipment, its problems are more familiar.

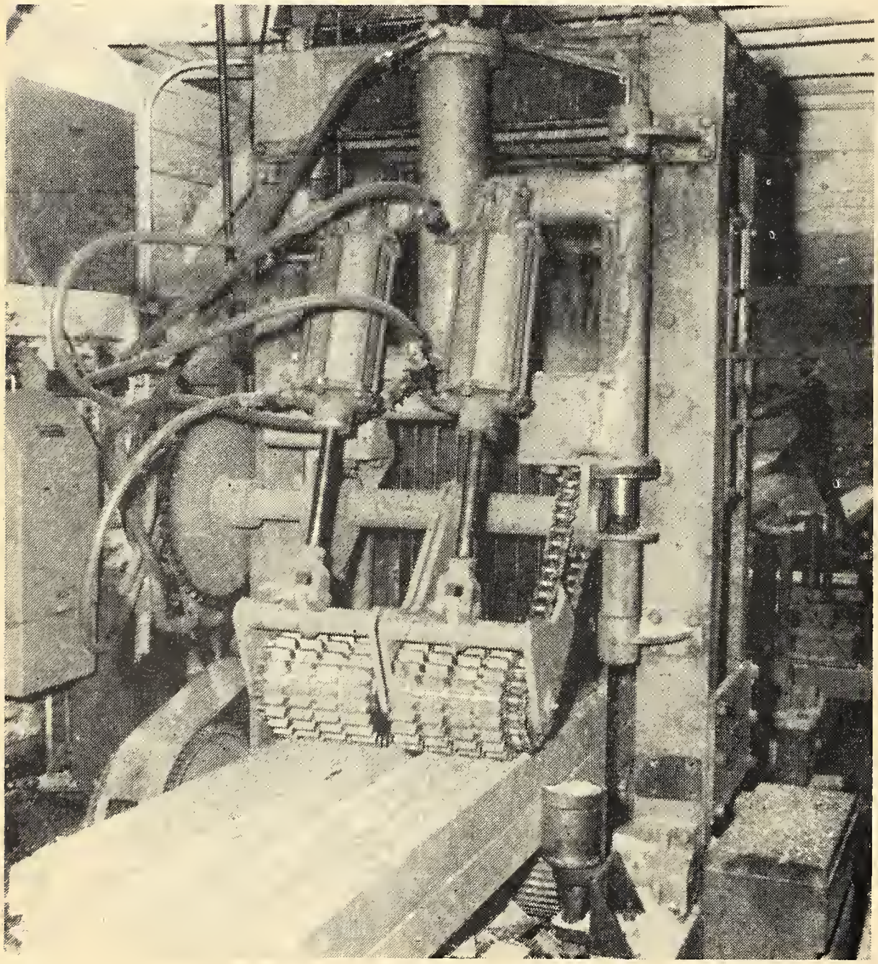
The feed drive for the saw may be built into the machine and driven from the main shaft, as in most intermittent feed applications or it may be powered by an independent drive motor, as is the case in the usual continuous feed saws. Quick and accurate variable speed control is always essential.

The most popular intermittent feed is a combination of cranks, rods and levers from the main shaft to wedge pawls and a vee grooved pawl wheel secured to a feed roll shaft. By means of an adjustable crank throw, the speed may be varied at the vee wheel by a change of the pawl advance per stroke. Reversal of the feed direction is built in to enable the saw to be cleared should the timber jam while cutting. Intermittent feed by hydraulic means is also used.

Continuous feed may be accomplished in several ways. A variable speed pulley drive or a hydraulic pump, and motor with speed control valve, taking power from the main shaft may be used. Separate electric motors driving mechanical or electrical variable speed devices are also popular, as are variable speed wound rotor and four speed motors. Where the drive is separate from the main shaft the customer can be offered a selection of drives, therefore, which vary in price and complexity.

Intermittent feed devices usually have a speed range of about four to one, while the continuous feed drives vary from this figure to about eight to one. Automatic speed control related to the timber size being sawn is also possible with the more expensive forms of the latter type drives. This factor may be worth while if a wide range of timber sizes is usual and maximum production rates are desired. Feed speed variations from 5 to 35 f.p.m. are found in a number of mills.

Fig. 4.



The main power drive for the average semi-portable saw is provided by an electric motor of from 50 to 100 h.p or in the more remote areas by a diesel engine of 100 to 150 hp. A jackshaft is normally incorporated to reduce the motor speed to that of the saw. Each make of saw has a speed at which it operates most efficiently. The most desirable one is that which will give the highest output from the mill and this can be worked out best by the individual operator to suit the materials and methods used, after he has tried out the saw at the manufacturer's recommended speed.

Vee and flat belts are used to transmit the power. The original and still popular all leather flat belt is extensively used although newer flat belts with leather outer faces separated by high strength plastic cores are gaining acceptance. Their popularity is based on the fact that once installed under an initial tension, they have very little subsequent stretch, unlike the other flat belts. Vee belts must be used in matched sets, to give equal loading. These belts should be renewed as matched sets, which is not always done, to ensure balanced loads and hence reasonable life.

In conclusion it should be stressed that, like other equipment for the timber industry in Canada and the United States, gangsaws must be ruggedly designed to take all kinds of abuse. Operating conditions vary widely, from mills where extreme care is taken of the equipment, to others where little maintenance and attention is paid to the saw until a breakdown occurs.

Most of the maintenance is performed by very practical men with not too much formal education, so that instruction books concerning operation must be worded simply and the important points emphasized in such a way that they are not buried in a mass of verbiage.

The field representatives and local distributors and dealers should be well trained in diagnosing trouble and helping the customer to keep his saw operating correctly. This will ensure a happy and long lasting relationship, as nothing travels faster and wider than bad news about a product. Additional sales of gangsaws are usually made to men who have looked over a number of installations and talked to their operators, with the result that a prejudice once formed is hard to eliminate. EIC

REVISION of the Concrete Section of the National Building Code

Mark W. Huggins, M.E.I.C.,
Professor, Department of Civil Engineering, University of Toronto

W. G. Plewes, M.E.I.C.,
Research Officer, Building Structures Section, Division of Building Research, National Research Council, Ottawa

The section of the NBC Code 1960 dealing with shear, bond and anchorage has been strengthened considerably. The new Code, to minimize cracking, requires more attention to shrinkage and to temperatures, and to methods of guarding against these effects

Presented at the 75th E.I.C. Annual General Meeting, Vancouver, May 1961.

BEFORE discussing the latest revisions to the concrete and reinforced concrete requirements of the National Building Code, it may be of interest to review briefly the history of standard regulations on concrete in Canada.

Prior to 1941, most major cities in Canada invoked building by-laws of their own design, which because of the magnitude of the problem involved in keeping them up to date, often became antiquated. Although smaller centres frequently made use of the knowledge and experience of the larger ones in preparing their regulations, there was a lack of uniformity between the building by-laws from one locality to another which was not only awkward on occasion, but not in the best interests of construction and commerce and hence not in the best interests of the public.

In 1941, under the sponsorship of the Department of Finance and the National Research Council, the first National Building Code of Canada was published. This document then became available as a model building code which any municipality could adopt or adapt as its own by-laws. In addition to convenience, the National Building Code offered the further advantage of regular revision which would make it easier for the municipalities to keep their own by-laws up to date. The sponsors hoped by this means to encourage uniformity of Building Codes in Canada.

Regarding the concrete section of the Code, it is necessary to go a little further back in history. In 1921 committees of the Canadian Engineering Standards Association, as the CSA was then called, began work on CESA A23 Standard Specification for Concrete and Reinforced Concrete. This was published in 1929. After revision a second edition of this specification was published in 1942.

In drawing up the concrete requirements of the NBC 1941, the responsible committee was guided by the work of the CSA Committees and close liaison was maintained between the two groups so that their respective documents were in close agreement except for minor details. Both of these agencies relied in turn on the American Concrete Institute Standard Building Code and the Joint Committee Report[19] for much of their material, although changes were made where differences in practice seemed desirable for Canada.

Following World War II, the Associate Committee of the National Building Code was established by the National Research Council. It set up Revision Committees to revise the 1941 Code and a new edition was published in 1953. In this case Part 4.5 dealing with concrete materials and construction was based on CSA Specification A23—1942, but Part 4.6 on reinforced concrete design was written to be in agreement with an unpublished draft of CSA Standard Recommended Practice for Reinforced Concrete Design which was not actually published until 1959. This document is in close agreement with ACI Standard

Building Code 318—1951.

When the Revision Committee on Concrete began its work for NBC 1960, a new CSA Specification on Concrete Materials and Methods of Construction was ready for publication. This was used in drawing up Sub-section 4.5.3 of the present Code as mentioned later. It was thought, however, that the CSA Code on reinforced concrete was in need of revision to bring it up to date with the American Concrete Institute Standard Building Code 318—1956, and also to incorporate the blue slip revisions to NBC 1953. For this reason the ACI Code was followed closely in preparing new articles on reinforced concrete design for NBC 1960.

Appointment of the Revision Committee

In preparation for the 1960 Revision of the National Building Code, the Associate Committee appointed a Revision Committee to review and revise Parts 4.5 and 4.6 dealing with concrete materials, design and construction. The members of this Committee were : Messrs. M. W. Huggins, Chairman, J. Hoogstraten, E. M. Rensaa, D. O. Robinson, O. Safir and W. G. Plewes, Secretary.

The revision work was to be done in two to three meetings, making use of whatever knowledge and experience was immediately at hand and without carrying out any new research or prolonged investigation. In line with the recommendations of the Advisory Structural Group, the American Concrete Institute Standard Building Code 318—56[1] was to be used as the basis for the NBC 1960 with regard to reinforced concrete design and CSA Specification A23.1—1960[2] with regard to concrete materials and methods of construction. The Committee could, however, propose whatever changes it thought desirable or practicable to make in the time available and drafts were to be circulated for comment.

Three drafts were prepared. The first was circulated to everyone who asked to be included on the circulation list and about 450 persons or organizations received a copy. The second draft was sent to all those who submitted comments on the first draft, about 50 in all. The third and final draft was submitted to the Associate Committee for approval.

All comments received were considered seriously by the Revision Committee and in many cases they resulted in a change or improvement in the succeeding drafts. Occasionally the Committee did not agree with the comment, but in a number of cases, although they were in agreement, they did not make a change because the evidence available was not sufficient to convince them that the change should be made, or because the subject was too large to draw up adequate clauses in the time available. Some of the more important changes that were made will now be discussed.

Shear, Bond, and Anchorage

By far the most important of the changes involves the problems of shear and the related problems of bond and anchorage of longitudinal reinforcement. In order to explain the new clauses, it is essential to review a little of the background history which has resulted in recent North American practice in dealing with shear, bond, and anchorage.

Many of the early studies of methods of shear reinforcement and their effectiveness were made in Germany 40–50 years ago by Morsch, et. al. Much of this testing has been reported in early American books such as [33]Principles of Reinforced Concrete[44] by Turneaure and Maurer.[3] As a result of the tests which indicated, among other things, the great effectiveness of bent up bars, the German code was written to require web reinforcement throughout the full length of beams and in addition the web steel was required to be designed to carry all shear at any point where the shear exceeded that which could be carried safely by the concrete alone. No allowance was to be made for concrete and web steel acting jointly in resisting shear.

This was, of course, a conservative approach to design and tests by Talbot[4] and others in America and elsewhere made it appear to be excessively so. As a consequence, a modification in design procedure was followed in North America in which the assumption of joint participation of web steel and concrete in resisting shear was permitted under certain design stresses ; namely $v = 0.03f'c$ to $0.06f'c$.

This practice was followed in North America for more than a quarter of a century without trouble. However, in 1955 and 1956 a series of shear failures of reinforced concrete frames in Air Force warehouses in the United States led to a serious re-examination of the then current building codes.[5] Since then many research programmes have been undertaken and many papers written in attempts to develop more suitable and safe methods of designing beams for shear.[5,6,7,8,9,10,11] Until such time as these new studies have been correlated and better Code provisions developed from the findings, an interim revision in the ACI Building Code was made in 1956 with the intent of preventing repetitions of the 1955/56 failures.

Since the 1953 NBC Code had been patterned after the 1951 ACI Code, it became immediately necessary to make similar modifications in NBC 1953. These changes, which were in fact more conservative than those in ACI 1956, were issued as revision slips. Consequently, when the Revision Committee was established in 1958 to prepare a new concrete and reinforced concrete section for NBC 1960, there had already been considerable thought given to the problem of shear and shear reinforcement and about two years experience in the operation of the revision slip clauses had accumulated. As a result of this experience, it had become apparent that some further modifications were necessary both for the purpose of simplifying the operation of the Code and for additional security.

The present section of NBC 1960 dealing with shear contains the following main changes from NBC 1953 :

(1) At discontinuous or unrestrained ends of flexural members where the unit shear v exceeds v_c (the allowable shear permitted for concrete without web steel) web steel is to be provided to carry at least $(2/3)v$, providing v is not greater than $0.06f'c$;

(2) In continuous flexural members, in which v exceeds v_c anywhere between an interior support and the point of inflection, web steel is to be provided for the total v between the face of the support and a point $l/10$ or d, whichever is the greater, beyond the point of inflection. In addition, the centre portion of a beam is to have web steel not less than required in (1) above or (3) below. At any point where v exceeds $0.06f'c$ web steel is to be designed to take the full v as in NBC 1953. The location of the point of inflection is to be calculated on the basis of maximum moment at the nearest support ;

(3) Minimum web steel to yield a steel cross section not less than 0.15% of the concrete area computed as the product of the width of the member at mid-depth and the horizontal spacing of web reinforcement is to be provided no matter how small v may be. The maximum permissible spacing of this minimum web steel where v is less than v_c is to be $(2/3)d$. This paragraph is not to apply to slabs or to beams whose ratio of b to d exceeds 4 ;

(4) The effective beam length which may be considered as reinforced by a bar bent up at an angle α is to be $d \cot \alpha$ rather than 3/4 the horizontal projection of the bend as in ACI 1956. This gives the bent up bar the advantage in design which numerous tests have indicated it justly deserves. In order that bent up bars may be considered effective as web steel α must not be less than 30°. The action of the combined web compression and bent-up bar tension acting in an imaginary truss is illustrated in Fig. 1.

The maximum permissible distance between successive bend up points for bars to be considered continuously effective in resisting shear is $d \cot \alpha$;

(5) The NBC 1941 formula for computing v in members varying in depth

was reinstated. This formula is

$$v = \frac{V \pm (M/d)\tan\beta}{bjd}$$

and is well known and needs no explanation.

In conjunction with the above changes in the shear clauses, the following important revisions were made in the bond and anchorage requirements :

1. Bent-up bars that are within $d/3$ of the longitudinal steel may be considered in calculating Σ_0 for bond.

2. In any span of a continuous, restrained, or cantilever beam, or in any member of a rigid frame at least 1/3 of the negative steel provided is to be extended beyond the extreme position of the point of inflection a distance sufficient to develop by bond one half the allowable fs, not less than $l/10$ and not less than d, whichever is greatest.

3. In simple beams or at freely supported ends of continuous beams at least one-third of the required positive steel is to be extended into the support a sufficient distance to develop by bond a force equal to two-thirds the shear at the support, but not less than 6 in.

This last clause was introduced to take account of the fact that the formation of diagonal tension cracks beginning near the face of a support causes the tension in the main longitudinal steel to be increased considerably. Thus in Fig. 2 it may be seen that, due to the crack, $T = (Va/jd)$. For example, if a were taken as $(5/8)d$ and j as 7/8, T would be $(5/7)V$. The correct value of a to be used is based on the location of the terminal point of the crack. It is felt that the new clause represents a reasonably conservative estimate of the maximum bar tension to be expected, although in many tests it has been shown that at ultimate a flexural member may tend to become simply a tied arch due to a gradual break down of bond between concrete and steel in the central portion of the beam. If complete bond failure were to occur except at the supports, the steel tension at a support would be the same as at mid-span. This obviously cannot occur in a well-designed beam, but the result of flexural cracking can be to cause very considerable increases in longitudinal steel tension.

The requirement of anchorage for $(2/3)V$ is a minimum. It is quite possible that loading conditions or span to depth ratios may be such as to require even better anchorage, which must be calculated by the designer by proper consideration of the potential effects of cracking.

4. Where, for practical reasons, stirrups must be anchored in a tensile zone, each end of the stirrup is to be bent over a longitudinal bar through 90° or more and is required to have an additional anchorage length of at least 24 stirrup diameters measured from the centre of bend.[12]

This change was made as a result of the conviction of the Revision Committee that such important shear resisting elements as stirrups should, if possible, always be anchored in a compression zone. However, recognizing the practical difficulties involved in providing compression zone anchorage in all cases, the requirements for tension zone anchorage were considerably stiffened beyond those of ACI 1956 which permits tight bending of stirrups through 180° around a longitudinal bar in a tension zone

Anchorage of stirrups by welding to longitudinal steel where the main reinforcement and stirrup steels are of suitable quality is permitted only with the approval of the authority having jurisdiction.

It is the writers' opinion that through the use of the above-described revisions in the shear, bond, and anchorage clauses improved concrete designs will result. Structures so designed should be much tougher and less brittle and should be able to withstand all working stresses induced in them with a minimum of unsightly cracking.

The material cost of providing this added safety and toughness may be seen by a comparison of the two designs shown in Fig. 3 for a typical interior span floor beam which has been designed as a monolithic continuous T-beam to carry a total uniform load of 2.05 KLF. The beam is one of a system of parallel beams at 6 ft. centres and when designed, following NBC 1960, requires 37 square stirrups weighing 78 lb. as compared with 6 U stirrups required by ACI 1956.

Stresses Due to Shrinkage and Temperature Change

The Code requires that the effects of volumetric changes due to shrinkage and temperature effects must be provided for in the design. The designer is permitted to calculate temperature and shrinkage stresses by assuming a 30° F. temperature drop over and above any actual drop in temperature. For concrete manufactured from light-weight aggregate this 30° F. allowance is made 60° F. Where close spacing of contraction joints (150–200 ft.) is provided the designer may avoid the detailed calculation of shrinkage and temperature stresses altogether.

The final responsibility for making adequate provision for the effects of shrinkage and temperature change still, of course, rests with the designer and there will be many situations in which the above approximate methods of computation will be inadequate. It must, therefore, be emphasized that these, along with all other Code requirements, are minima to be supplemented where calculations indicate the necessity.

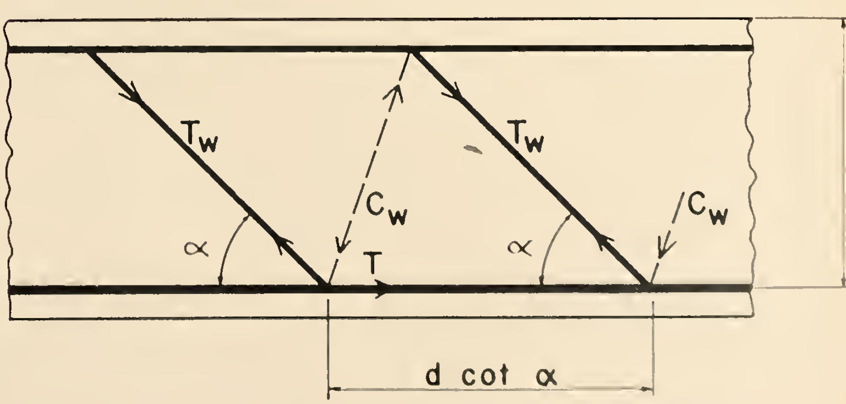
Crack Control

Throughout the reinforced concrete section of the code numerous changes were introduced with the object of obtaining better control over cracking of concrete with resulting longer-lasting, safer structures.

The above requirement, that shrinkage and temperature stresses shall be provided for in all designs, is one important instance of this type of change. However, in order to avoid applying excessive penalties to designs in which careful consideration has been given to shrinkage and temperature the permissible stresses where such effects are combined with dead and live load effects are increased by one third.

A second and major change was introduced in NBC 1960 with the adoption of the Marcus Method[13,14] of designing two-way slabs. This method was first proposed over 30 years ago and has been in use in Germany and Great Britain for many years and it is understood that it is being seriously considered for inclusion in the

Fig. 1.



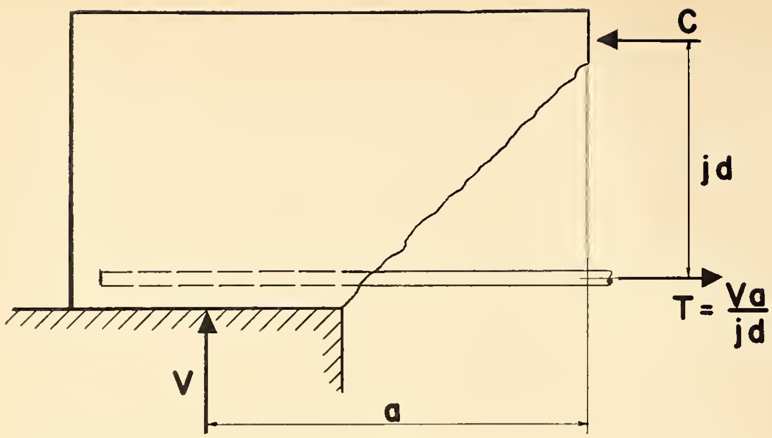


Fig. 2.

next revision of the ACI Building Code. The tabulation of co-efficients which appears in the Code is one which was compiled by Paul Rogers who is a member of the ACI Building Code Committee, and was made available to the Revision Committee through their generosity. Table I provides a comparison between the moment coefficients of NBC 1960 and ACI 1956, Method 2.

Examination of the table shows that the negative moment coefficients are generally lower and the positive moment coefficients higher by ACI Method 2 than in the new NBC two-way slab requirements. Also relatively more moment resistance is attributed to the *B* spans of long rectangular slabs. It is believed that the ACI coefficients were adjusted from elastic analyses to take into account inelastic action and redistribution of moments as the slab approaches failure. The Marcus Method approximates more closely the moment situation and behaviour of the slabs at working load. This is probably the better approach because as Ferguson[15] says, "One can almost say that any arbitrary arrangement of steel, in sufficient quantity to carry the load, will be developed before a slab completely fails."

It should also be noted that both the ACI and NBC Codes specify a minimum amount of negative reinforcement at discontinuous edges.

The Marcus Method is a modification of the old "crossed sticks" formulas in which load was assumed to divide between the long and short spans inversely as the fourth power of the spans. Dr. Marcus introduced a very simple approximate adjustment which takes account of torsion and corner effects so efficiently that the resulting positive moments have been found to agree very closely with moments calculated by rigorous elastic plate theory.

The reason for making this Code change was that it has long been known that method 2 of ACI 1956 led to serious underestimation of negative moments with resulting slab cracking and on the other hand method 1 of ACI 1956 which is more accurate than method 2 was not

TABLE 1

COMPARISON OF MOMENT COEFFICIENTS FOR TWO-WAY SLABS AS GIVEN IN NBC-1960 AND METHOD 2 OF ACI 318-56*

$M_A = C_A w A^2$ $\qquad$ $M_B = C_B w B^2$

Direction of Span	Ratio *A/B*	*Case 1*	*Case 2*	*Case 3*	*Case 4*	*Case 5*	*Case 6*	*Case 7*	*Case 8*	*Case 9*
					NEGATIVE MOMENTS AT CONTINUOUS EDGES					
Short Span A	1.0		.045(.033)		.050(.049)	.075(.049)	.071(.058)		.033(.041)	.061(.041)
	0.7		.074(.055)		.081(.071)	.086(.071)	.091(.082)		.068(.062)	.081(.062)
	0.5		.086(.083)		.094(.090)	.090(.090)	.097(.098)		.089(.085)	.088(.085)
Long Span B	1.0		.045(.033)	.076(.049)	.050(.049)			.071(.058)	.061(.041)	.033(.041)
	0.7		.017(.016)	.050(.024)	.019(.024)			.038(.028)	.029(.020)	.011(.020)
	0.5		.006(.008)	.022(.012)	.006(.012)			.014(.014)	.010(.010)	.003(.010)
					*POSITIVE MOMENT COEFFICIENTS***					
Short Span A	1.0	.036(.050)	.024(.025)	.024(.037)	.030(.037)	.030(.037)	.034(.044)	.030(.044)	.025(.031)	.028(.031)
	0.7	.068(.072)	.043(.041)	.053(.054)	.053(.054)	.046(.054)	.057(.062)	.061(.062)	.049(.047)	.044(.047)
	0.5	.095(.083)	.056(.062)	.085(.068)	.071(.068)	.058(.068)	.072(.074)	.091(.074)	.069(.064)	.057(.064)
Long Span B	1.0	.036(.050)	.024(.025)	.030(.037)	.030(.037)	.024(.037)	.030(.044)	.034(.044)	.028(.031)	.025(.031)
	0.7	.016(.024)	.010(.012)	.016(.018)	.013(.018)	.009(.018)	.012(.022)	.017(.022)	.013(.015)	.010(.015)
	0.5	.006(.012)	.003(.006)	.007(.009)	.005(.009)	.003(.009)	.004(.011)	.007(.011)	.005(.008)	.003(.008)

NOTES:

* ACI Method 2 coefficients are given in brackets and are converted to $C \times w \times (\text{Long Span})^2$ in the case of the *B* spans.

** The ACI coefficients are given in terms of $C \times w \times (\text{Span})^2$ where w is the total $LL + DL$ per square foot regardless of the LL/DL ratio. The NBC moment coefficients are given separately for *LL* and *DL*. In comparing the two, it is necessary to convert the *NBC* coefficients to an average coefficient which may be applied to the total load w. It is also necessary to consider a specific LL/DL ratio. In this table a LL/DL ratio of 2 has been assumed and the coefficients computed as follows:

$$\text{Average Coefficient} = \frac{DL\ \text{Coefficient} + 2 \times LL\ \text{Coefficient}}{3}$$

popular because of complications involved in its application. It is the writers' opinion that the application of the Marcus Method through the use of the tables provided in the Code will prove to be simple and will at the same time result in slabs with improved service behaviour, as compared with NBC 1953 designs.

An important innovation in the new tables is the provision for calculation of positive dead and live load moments separately. This gives the designer an opportunity to make a more accurate assessment of the effects of checker board loading. No such provision is made for calculating negative moments separately due to the fact that maximum negative moments occur when adjacent spans are loaded simultaneously. The effect on support negative moment of omitting live load on the next remote spans is considered to be negligible on account of the relatively high torsional stiffnesses of the supporting beams.

As further insurance against unsightly and sometimes dangerous cracking of slabs of all types the maximum permissible spacing of reinforcing designed to resist calculated moment is $2\frac{1}{2}t$, but not greater than 15 in. The corresponding maxima for shrinkage steel are $3t$ and 18 in. No differentiation is made between floor and roof slabs insofar as the above maximum permissible spacings are concerned.

Shrinkage steel requirements for walls were increased appreciably with the intent of minimizing the type of cracking which occurs so commonly around door and window openings and in long walls without sufficient contraction joints. Many of these changes merely codified what has long been recognized as good engineering practice in crack control.

The most important changes which were made in wall reinforcing requirements are as follows:

(1) The minimum percentage of horizontal reinforcing is 0.00375 rather than 0.0025 where the wall is longer than 30 ft. and control joints are spaced at greater than 30 ft. centres.

(2) "In addition to the minimum reinforcement prescribed in Paragraph 19, there shall be not less than two No. 5 bars around all window or door openings. Such bars shall be adequately anchored beyond the corners of the openings. If the wall is more than 30 ft. long and not divided by contraction, expansion, or control joints with a maximum spacing of 30 ft., the diameter of the two bars shall be increased one-eighth of an inch for each 30 ft. increment of length up to a maximum of two No. 8 bars. *Such* bars shall be placed in continuous lines for the full length of wall at the top and bottom of foundation walls and at the top of all walls. More than two bars with an equivalent total cross-sectional area may be used."

In this clause, which has been quoted verbatim from the Code, *such* should have been "similar". It was the Committee's intention that bars identical in size to those specified for door and window openings should be placed at the top and bottom of foundation walls and at the top of all walls. If a foundation wall contains nearly continuous window openings, it will be necessary to use four lines of reinforcing of the size specified, i.e., at the top and bottom of the windows and top and bottom of the wall. In addition two No. 5 bars are required at each vertical side of a window. (Figs. 4 and 5.)

Deflection Control

In view of the considerable number of problems which have arisen in recent years due to excessive deflection, particularly in the case of precast structures both in heavy stone concrete and light weight aggregate concrete, careful consideration was given to ways and means of preventing such faults in future construction.

For stone concrete the new Code includes a table of minimum over-all slab and beam depths expressed as fractions of the span for one-way slabs and beams and for various types of end restraint. These requirements are shown in Table 2 of this paper, which has been taken from the Code. In addition, it is required that structures manufactured of light weight concrete shall have their dimensions so adjusted as to yield the same limiting deflections as for heavy stone concrete. For the purpose of applying the above requirement, the testing method for determining Young's Modulus of any light weight concrete is prescribed. Eighty per cent of the established test value of E is to be used in making deflection calculations. This is to provide for the fact that the average strength of concrete as determined by test must exceed the design strength, which has been taken as the criterion in drawing up the requirements of Table 2.

TABLE 2

Member / Type of support	Minimum thickness t — Simply Supported	One end Continuous	Both ends Continuous	Cantilever
One-way slabs	$l/25$	$l/30$	$l/35$	$l/12$
Beams	$l/20$	$l/23$	$l/26$	$l/10$

It was not considered practical to make provision for possible differences in plastic creep behaviour of light weight aggregate and standard aggregate structures other than through application of the above clauses.

Provision is made for modification of the above minimum overall depth requirement in the case of stone concrete where calculations prove that the dept can be reduced without adverse effects

It was not possible for the Committee to deal adequately with all of the problems which are special to precast concrete and light weight concrete in the time available. It is the authors' opinion that the above provisions are such as to insure against excessive deflections, but there are many other problems special to this rapidly-expanding and important branch of reinforced concrete which require the attention of a committee or committees of NBC or CSA set up specifically to study them and develop proper Code provisions.

Flexural Computations

The Code provides for approximate methods of frame analysis for buildings of usual types of construction, spans and storey heights with the same limitations and coefficients as in ACI 1956, with the exception of the positive moment coefficient for end spans which has been made 1/11 as compared with 1/14 and 1/11.

In the ACI Code 1/11 is used with an unrestrained, discontinuous end support and 1/14 where the beam is integral with an end support. The change was made because of lack of confidence in the type of end support normally provided.

Where the designer chooses to determine moments by accurate elastic methods of calculations, he may take account of the actual condition of end restraint. At the same time he is permitted to adjust the negative moments at the supports, for any assumed loading, by not more than 15% provided that these modified negative moments are used for the calculation of the corresponding positive moments in the span.

The purpose of this clause is to permit the designer to take some account of the plastic behaviour of concrete where he feels that a more efficient use of materials may result. However, the use of ultimate strength design methods is not provided for in the Code since it was the feeling of the Revision Committee that this would have required much more time than was available for the revision.

The Code also requires that in continuous beams and slabs of different span lengths, the positive moment shall in no case be assumed less than would be assumed for a fixed condition at the sup-

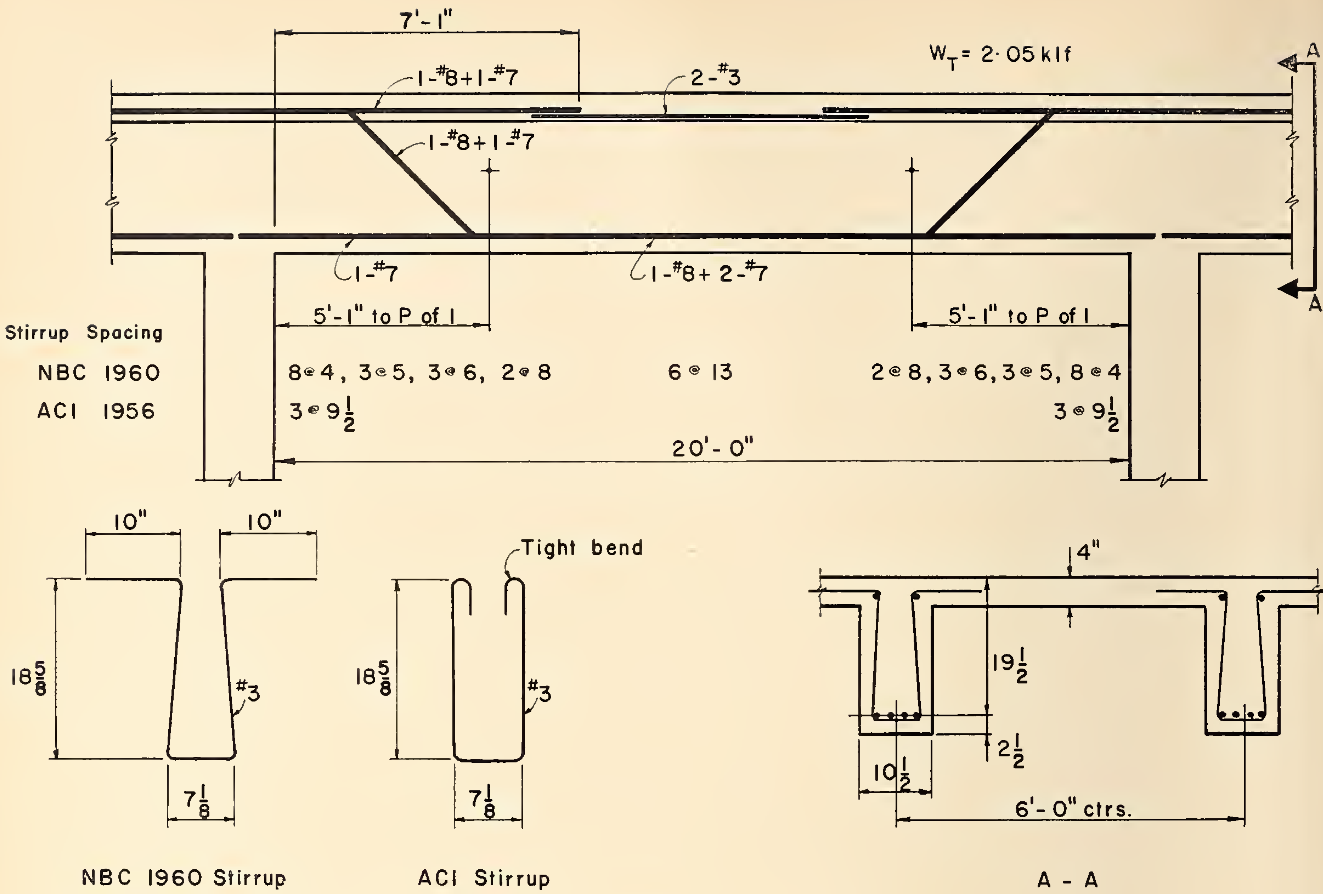


Fig. 3.

port or supports as the case may be. This provision is intended for cases of accidentally, seriously unbalanced live load where usual methods of analysis might indicate very low positive or even negative moment throughout a span. It is also required that, except in slabs of uniform thickness, wherever analysis indicates a need for positive reinforcement, the amount provided shall be not less than $0.005b'd$ for T-beams and $0.005bd$ for rectangular beams.

Rectangular and upturned beams are required to have a minimum reinforcement on the compression side of $0.003bd$, placed adjacent to the outer faces of the beam. The purpose of this requirement is to ensure that possible buckling of the compression portion of the beam will be resisted by steel just as it is resisted in reinforced concrete columns for which minimum longitudinal steel is also specified.

Welding and Tension Splices

As referred to previously under shear, welding of stirrups to longitudinal steel is permitted provided the steels are of suitable quality and the approval of the authority having jurisdiction is granted.

Where tension splices are required, definite rules are laid down regarding acceptable types.

Welded tension splices are permitted only when the steel is of suitable quality and with the approval of the authority having jurisdiction. The minimum overlap for a lapped tension splice is 36 bar diameters. Whether the splice is by welding or by lapping centres of splices in parallel bars shall be offset at least 42 bar diameters. In any case, not more than one-fifth of the tensile reinforcement is to be spliced at the same section, unless tests prove to the authority having jurisdiction that a greater proportion may be safely spliced at the section.

Where lapped tension splices are used in beams or direct tension members, ties are required having a diameter not less than one-quarter that of the spliced bars and spaced not farther apart than 10 bar diameters along the full length of the splice to prevent splitting.

The general philosophy of the Revision Committee in the preparation of the above clauses relating to splices might be stated as follows:

(1) Although not opposed to welding, the Committee felt that, before approving of anything more than one-fifth of the bars to be welded at any section, it would be necessary to have a Code providing much closer control over steel quality and welding quality than is at present available on the normal reinforced concrete project.

(2) Because of the tendency of cracks to form at the ends of tension bars in tension concrete zones and the generally accepted opinion that anchorage of steel in tension zones should be avoided, a conservative approach should be taken with respect to the use of tension lapped splices. Reports by more than one investigator[15,16] indicate that the danger of concrete splitting is serious where large diameter bars, with accompanying large bond stresses, are used. The Committee therefore decided to adopt a conservative approach in setting up the above lapped splice clauses.

The requirement of 36 bar diameters lap is approximately 50% higher than has been indicated, in some tests, as required for full development of the tensile strength.[16] On the other hand, tests by others[15] have shown excessive spalling and cracking, particularly with large deformed bars. The 36 bar diameter lap should serve to provide a more gradual transfer of stress, while the 42 bar diameter stagger should provide sufficient separation of the areas of stress concentration at the bar ends.

Chamberlin's tests[16] show that ties result in about a 25% increase in strength, particularly in splices of deformed bars for which splitting is a problem.

It is expected that the combined

effects of the application of the above splice clauses will provide security where tension splices must be used and also ensure satisfactory performance without cracking or spalling under normal loading.

Columns

The column section of the Code is essentially the same as ACI 1956 with a few minor modifications.

(1) No minimum cross section requirements are applied to precast concrete. The main reason for such limitations on cross sections of columns in the past has been the difficulty in placing concrete in small sections. This problem is greatly reduced when columns are cast in a horizontal position as is usual in precast members.

(2) The minimum dimensions for principal cast-in-place columns are reduced to not less than 12-in. diameter, not less than 100 sq. in. for rectangular sections, and the least lateral dimension of the same, not less than 8 in.

In the case of short rectangular columns (not exceeding 7 ft. in height) the minimum permissible cross sectional area is 50 sq. in. and the minimum permissible lateral dimension is 6 in. These are usually minor columns less than one storey in height, e.g. posts under stair landings.

These changes have been made to take account of the existence of improved methods of placing concrete. It must still be the designer's responsibility to assure himself that the dimensions he has selected for any particular column will be such as to permit the production of good quality cast-in-place columns.

(3) The maximum permissible ratio h/t remains as in ACI 1956. However, where complete and detailed calculations are made in which the actual end restraints and eccentricities and the effects of shrinkage and plastic flow are properly provided for this ratio may be increased to 30.

The Codes of many other countries permit considerably more slender columns than those permitted by NBC 1953 and ACI 1956. It is the Committee's firm conviction that such columns may be safely designed, but that much more care must be exercised than in the usual building column design operation.

(4) NBC 1960 is nearly identical with ACI 1956 with regard to design and analysis of eccentrically loaded columns. The ACI formulas

$$\left(\text{e.g. } \frac{fa}{Fa} + \frac{fb}{Fb} \not> 1\right)$$

which are of the interaction type for e/t ratios not greater than 2/3 are simple to use, are well established and are based on an assumed uncracked section. However, NBC 1960 contains a clause which requires that, where 50% or more of the bending stress f_b is due to moments caused by horizontal loads and e/t exceeds 1/3, the cracked section method of computation is to be used.

The purpose of this clause may best be explained by a discussion of the philosophy behind the use of the uncracked section theory for e/t up to 2/3.

In permitting the assumption of an uncracked section for an e/t ratio as high as 2/3, it has been argued that plastic flow of the compression concrete combined with possible cracking of the tension concrete will result in some relief of the bending moment put into a column by vertically loaded beams or girders. It was the Committee's opinion that it would be unwise to rely on such relief of moment where the cause of the moment was horizontal loading rather than vertical.

Footings

This portion of the code is nearly identical with ACI 1956 except that:

(1) tensile reinforcement in two-way reinforced footings is to provide a moment of resistance at least equal to 100% of the moment on a section computed by the ACI 1956 method rather than 85% as required by ACI.

It has been pointed out by Richart,[17] Ferguson[15] and others that the 85% quirement was the result of an earlier erroneous method of calculating the bending moment.

(2) A clause has been added requiring the tensile reinforcement in any direction to have an embedment length beyond the critical section for shear sufficient to develop the allowable stress in the steel at the bond stresses allowed for footings.

Whitney[9] has shown that, in order to obtain full efficiency of reinforcement, the length of embedment outside the pyramid of rupture must be capable of developing the yield strength at the point where it intersects the pyramid of rupture.

High Tensile Steel

No provision has been made for the use of high tensile steels except as in ACI 1956 where in the case of one-way slabs of not more than 12 ft. span where the permissible tensile stress for main reinforcement, 3/8 in. or less in diameter, has been set at 50% of the minimum specified yield point in the CSA specification, but in no case to exceed 30,000 p.s.i.

There was considerable support for the immediate adoption of higher allowable steel stresses in general. However, it was the Committee's opinion that there were still too many problems to be answered satisfactorily with respect to the effects of higher stresses on cracking and bond stresses to permit an upward revision of the allowable stresses without considerably more time for study than was available. It is the writers' conviction that this problem is in need of immediate study by a committee set up especially for the purpose, so that the efficient use of higher strength steels may

Fig. 4.

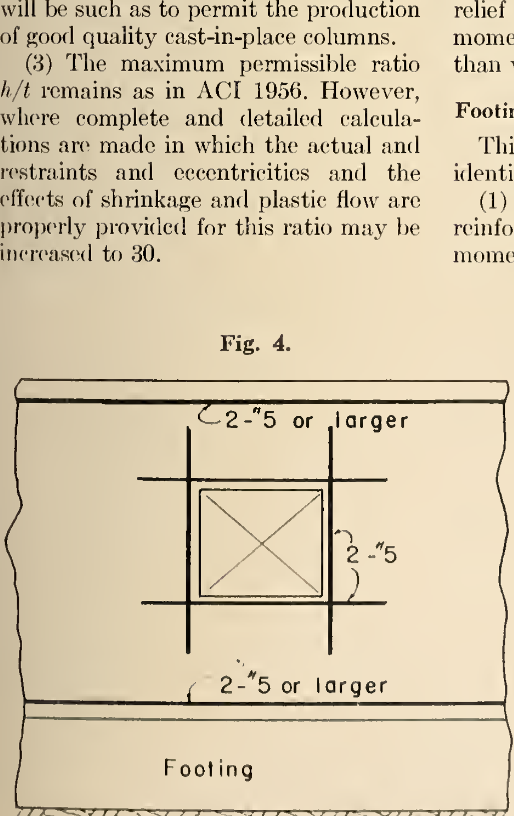
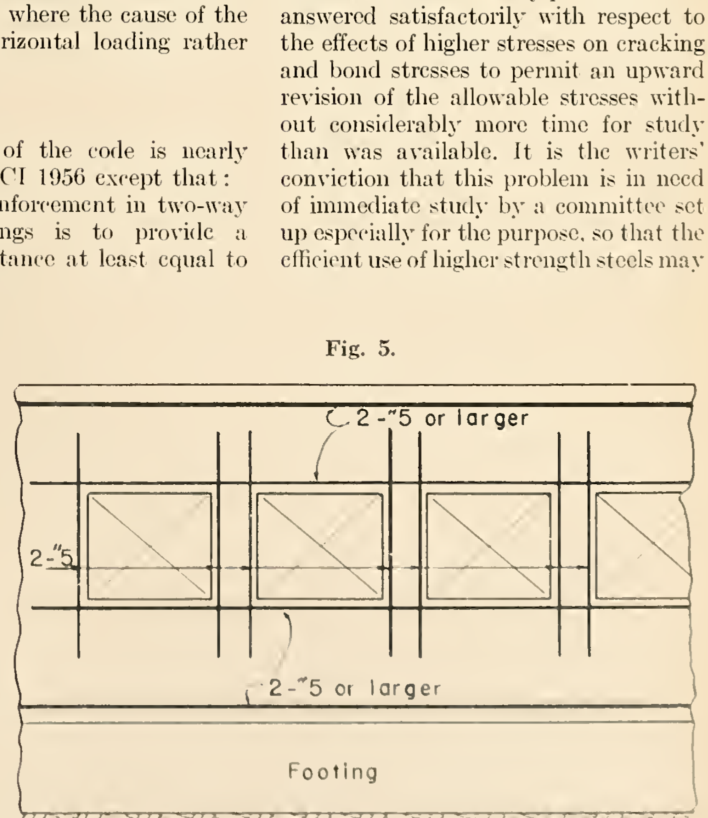


Fig. 5.



be provided for in the next NBC revision.

Concrete Materials

The section of the Code dealing with concrete materials and methods of construction other than reinforcing steel is based almost completely on CSA-A23.1 Code for Concrete Materials and Methods of Concrete Construction. This CSA document, published last December, is the result of a long and intensive effort on the part of a CSA committee under the Chairmanship of Hugh Ross of the Hydro Electric Power Commission of Ontario.

Matters pertaining to concrete materials are dealt with by reference only to the CSA standard, but clauses concerning important details of construction are printed in the Code since such information is often closely connected with design.

Precast Concrete

As mentioned earlier under the heading of deflection, the Revision Committee did not have time to deal adequately with the special problems pertaining to precast construction. The Code requirements are essentially those of ACI 1956 plus a slightly modified repetition of the NBC 1953 rules for precast concrete joist floors. A thorough Committee study with a view to preparing a specification for this important type of construction is urgently needed in view of its rapidly increasing use.

A few of the problems special to this field and not properly dealt with in NBC 1960 are :

1. Working stresses, especially in shear and bond for light-weight concrete ;

2. Cover to reinforcement—should it be less in precast?

3. Accurate methods of predicting shrinkage and creep. These are particularly important in deflection and warping calculations ;

4. Connections and details—this is a difficult problem and is already being intensively studied by many individuals ;

5. Working stresses for temporary connections ;

6. Anchorage ;

7. Bar spacings—minimum less when precast and vibrated?

8. Relative strengths and stiffnesses of monolithic cast-in-place concrete and structures made from precast elements joined by mechanical anchors ;

9. The use of welding in precast work —field and shop.

Prestressed Concrete

The Code requires that "the materials, design and construction of prestressed concrete structural members shall comply with CSA specification Design and Construction of Prestressed Concrete".

Although the reference CSA specification had not been completed at the time of printing of the Code, the Revision Committee was aware of the general nature of the proposed specification and was given an estimate of the probable time of its publication as sometime during 1961.

It is anticipated that the final form of the CSA specification will be similar to ACI—ASCE Joint Committee 323—Tentative Recommendations for Prestressed Concrete, but will differ from it in some very important respects. The most important difference, of course, will be that it is a specification rather than a recommended practice. In writing a specification, the CSA Committee has found it necessary to be much more definite about many points than the ACI document, with the consequence that many completely new clauses have been required.

Generally it may be stated that the allowable stresses and required ultimate safety factors are likely to be the same, but that in areas involving shear and bond there will be appreciable differences.

Concluding Remarks

With NBC 1960 now published, it is apparent that the never-ending task of revision must be carried on. At the time of the next revision it should not be necessary to say that :

(1) Satisfactory clauses for welding could not be written because of the lack of a suitable welding Code and inadequate inspection requirements in normal construction ;

(2) The special problems involving precast concrete, and light-weight concrete were too numerous to be dealt with by the Committee in the time available ;

(3) Clauses permitting the use of high tensile steel reinforcement and ultimate strength design were not included because of lack of sufficient research evidence and insufficient time for the thorough study which would have been necessary

These outstanding problems have been brought to the attention of the responsible bodies of the NBC and CSA respectively and it is understood that steps are being taken for an extensive review of the Concrete Section of the Code before the 1965 revision.

If this commentary has done nothing else, it is hoped that it has pointed out clearly some of those areas in which further study is needed by whatever group or groups are responsible if we are to make efficient use of our engineering talent and safe as well as efficient use of our natural resources in reinforced concrete construction.

References

1. American Concrete Institute, Building Code Requirements for Reinforced Concrete (ACI 318-56).
2. Canadian Standards Association Specification A23-1—1960 Code for Concrete Materials and Methods of Concrete Construction.
3. Turneaure, F. E. and Maurer, E. R., Principles of Reinforced Concrete Construction, John Wiley & Sons Inc., 4th Edition.
4. Talbot, A. N., "Tests of Concrete: I Shear", Bulletin No. 8, University of Illinois, 1906.
5. Anderson, Boyd G., Rigid Frame Failures, ACI Journal, V. 28, No. 7, Jan. 1957, pp. 625-636.
6. Rensaa, E. M., Shear Diagonal Tension and Bond Stresses in Reinforced Concrete Beams, The Engineering Journal, V. 40, No. 10, Oct. 1957, pp. 1464-1471.
7. Rensaa, E. M., Shear, Diagonal Tension and Anchorage in Beams, ACI Journal, V. 30, No. 6, Dec. 1958, pp. 695-715.
8. Elstner, Richard C., and Hognestad, E., Laboratory Investigation of Rigid Frame Failure, ACI Journal V. 28, No. 7, Jan. 1957, pp. 637-668.
9. Whitney, Charles S., Ultimate Shear Strength of Reinforced Concrete Floor Slabs, Footings, Beams and Frame Members without shear Reinforcement, ACI Journal, Vol. 29, No. 4, Oct. 1957.
10. Taub, J. and Neville, A. M., Resistance to Shear of Reinforced Concrete Beams, Parts 1 to 5, ACI Journal, Vol. 32, Nos. 2 to 6, August to December, 1960.
11. Taylor, R., Some Shear Tests on Reinforced Concrete Beams Without Shear Reinforcement. Magazine of Concrete Research, Vol. 12, No. 36, November, 1960.
12. Hajnal-Konyi, K., Discussion of Paper by E. M. Rensaa, Shear, Diagonal Tension and Anchorage in Beams, ACI Journal, Vol. 30, No. 12, June, 1959.
13. H. Marcus, Die vereinfachte Berechnung biegsemar Platten, Bauingenieure, Bd. 5, Heft 20/51, 1924.
14. Rogers, Paul, Two-Way Reinforced Concrete Slabs, ACI Journal, Vol. 16, No. 1, Sept. 1944.
15. Ferguson, Phil. M., Reinforced Concrete Fundamentals, John Wiley & Sons Inc.
16. Chamberlin, S. J., Spacing of Spliced Bars in Beams, ACI Journal, Vol. 29, No. 8, Feb. 1958.
17. Richart, F. E., Reinforced Concrete Wall and Column Footings ACI Journal, Vol. 45, Oct. & Nov. 1948.
18. Wastlund, G., Use of High Strength Steel in Reinforced Concrete, ACI Journal, Vol. 29, No. 12, June, 1959.
19. Recommended Practice and Standard Specifications for Concrete and Reinforced Concrete, Report of Joint Committee; published by ACI, June 1940, 140 pp.

EIC

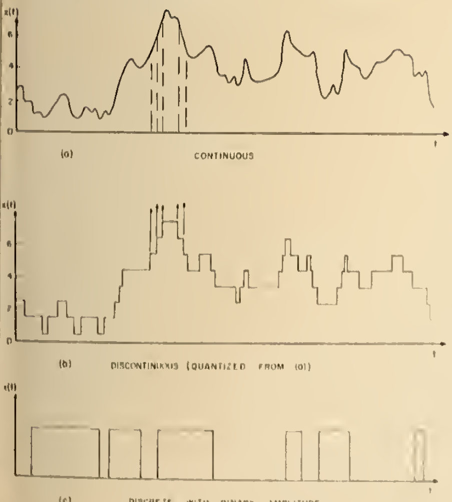
J. H. Milsum,
Dept. of Electrical Engineering
McGill University,
Montreal.

RANDOM VARIABLES IN ENGINEERING DESIGN

Presented at the 75th E.I.C. Annual General Meeting, Vancouver, May 1961.

THE UBIQUITY of significant statistical effects in engineering systems has become increasingly recognized by designers in recent years, resulting in considerable changes in many design procedures. Thus a design for statistical (stochastic, random) signals has augmented or even replaced classical design procedures based upon steady-state, sinusoidal or transient inputs.

Fig. 1. Some stochastic variables



Most engineering systems are affected by natural signals, all of which are at least partially random, for example, rainfall, waves, wind, air temperature, earthquakes, ground roughness and cosmic radiation. Furthermore randomness is generated within engineering systems by various man-made components, for example, vacuum tubes. Stochastic signals are important to the complete spectrum of engineering systems, from the low-power "communications" field (e.g. utilization of telephone channels) through to the heavy "power" field (e.g. rainfall and consumer electrical loads are both stochastic and both affect hydro-electric power systems design).

Treatment of stochastic signals was pioneered by the communications field, but interest from other fields has increased rapidly. This is attributable, partly at least, to the general "tightening" in design procedures in recent years, as design has become more scientific; for instance, more hydrographic data is becoming available while our unutilized supplies of fresh water are being exhausted, so that we must use what is available as efficiently as possible. Also we should note that design of large systems with stochastic variables has only become practicable with the advent of high-speed, electronic computers (both analog and digital).

This paper will attempt to summarize the important properties and treatment of stochastic signals from an engineer's viewpoint. It is therefore largely tutorial, and the reader is referred to the many excellent textbooks[1-5] and specialist articles available in the literature for deeper study. For readers completely new to statistics, this paper is complemented by the very elementary introduction[6] by the author.

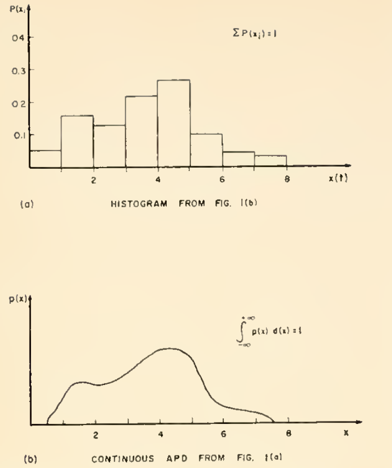


Fig. 2. Amplitude probability density (APD) functions

Description of Stochastic Signals

Individual time histories of natural stochastic signals may be available in many cases; for example, earthquakes and ambient temperatures. Such stochastic signals often exhibit a definite periodicity, due to such effects as lunar attraction, and earth's rotation. Nonetheless there is a sufficiently large random fluctuation that the time history of such a signal cannot be described explicitly; in other words the signal's time history cannot be reproduced by simple calculation from a formula. However, satisfactory descriptive measures must be available if the engineer is to predict and carry out simulated experiments on the effects of such signals upon his aircraft, buildings, breakwaters, radar communication, etc. Thus he utilizes the results of statistical theory and specifies only a small number of average measures. Typically one or two measures must be known and these specify only a *class* of random signals, within which there is an infinite number of actual time histories possible.

Probability measures are defined for an *ensemble* of similar stochastic records sampled simultaneously. If the values of given measures do not change when the sampling is done at different points in time, then the stochastic variable is said to be *stationary*. Then the *Ergodic Hypothesis* is satisfied and one may calculate the statistical measures by taking samples from one record only, spread in time.

In the following sections we consider the common measures and some results of engineering importance, with examples. The measures are,

(i) The probability density function, $p(x)$, including the Gaussian or Normal, and the moments of this function, especially

(a) the mean, μ

(b) the standard deviation, σ

(ii) The auto-correlation function and its Fourier transform the power spectral density.

The following concepts are also mentioned:

(i) Stationarity

(ii) Confidence (in statistical measurements)

(iii) Filtering

(iv) Extreme-value statistics.

We should note that both continuous and discontinuous random signals are of engineering importance (although all signals are quantized of course at the microscopic level). The height of waves at a particular point on a body of water, for example, may be considered continuous in both amplitude and time (Fig. 1(a)). If now we use an instrument which measures only to the nearest foot, then we have quantized the continuous signal (Fig. 1(b)). In each case, however, we need both an amplitude measure, $p(x)$, and a frequency (or time) measure (the power spectral density, or auto-correlation functions). On the other hand, in a single-channel telephone line there is only binary amplitude discrimination (i.e., there *is* or *is not* a call in progress at any time, (Fig. 1 (c)). Only one measure is now needed, namely, the time measure. These points will be discussed more fully later.

Probability Density Function

The probability density function is a measure of the relative frequency of occurrence of the possible signal values. Signal amplitude is the most frequently used variable and the function is then called the amplitude probability density function, $p(x)$. The magnitude of $p(x)$ at any x is defined by,

$$\text{probability}\left\{x - \frac{dx}{2} < x < x + \frac{dx}{2}\right\} = p(x)dx$$

The amplitude probability density for Fig. 1(a) is sketched in Fig. (2b).

When a quantized signal such as in Fig. 1(b) is taken, a probability histogram is obtained as shown in Fig. 2(a). Each part of the histogram represents a finite probability $P(x)$. Both functions must satisfy the unit probability condition that some amplitude occurs, viz.

$$\int_{-\infty}^{+\infty} p(x)\cdot dx = 1 \text{ or } \sum_i P(x_i) = 1 \quad (1)$$

Moments of the Amplitude Probability Density: Eq. 1 actually represents the zero-th moment of the amplitude probability density. Moments are important measures of stochastic variables, of which the first and second are widely used by engineers under other names. The n-th moment of the amplitude probability of a continuous stochastic variable is defined as,

$$\nu_n(x) = \int_{-\infty}^{+\infty} x^n \cdot p(x)\cdot dx \quad (2)$$

(i) *The mean*—or first moment, ν_1,

$$\nu_1(x) = \mu = \int_{-\infty}^{+\infty} x \cdot p(x)\cdot dx \quad (3)$$

This is the commonly-met mean or average value of a signal.

(ii) *The mean square value*—or second moment, ν_2; actually for $n > 1$, we usually work with the *central* moments (μ_n) i.e.

$$\mu_2(x) = \sigma^2 = \int_{-\infty}^{+\infty} (x - \mu)^2 \cdot p(x)\cdot dx \quad (4)$$

σ^2 is the mean square deviation from the mean, i.e. the variance of the variable, and σ is the standard deviation.

The higher moments also become of interest in some engineering problems. Now the particular amplitude prob-

Fig. 3. Some useful probability density functions (normalized)

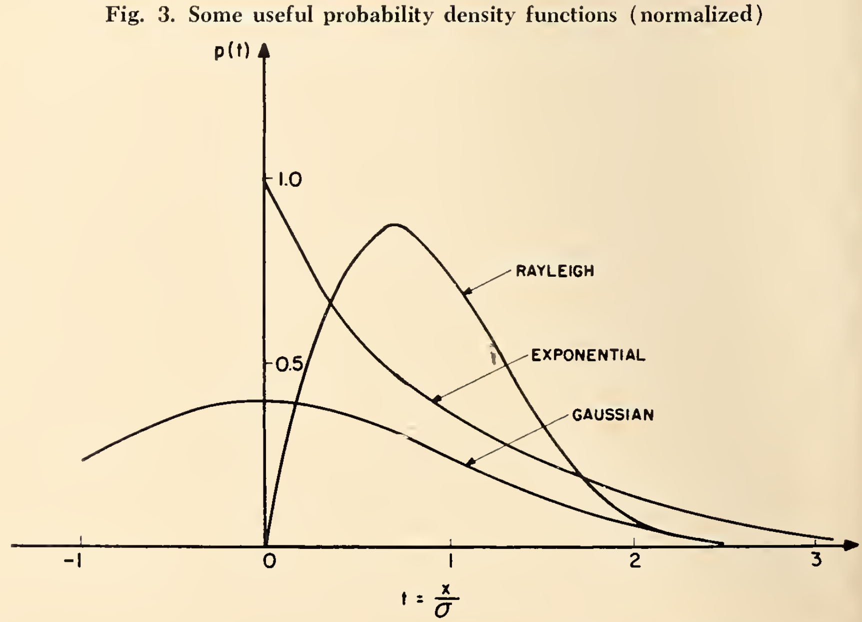


Fig. 4. Sample of filtered output voltage from random noise generator

ability of Fig. 2 has no general interest because it was derived from a short section of hand-drawn curve, and we merely note in passing that it has two peaks and is therefore called *bimodal*. However, there are several mathematically derived amplitude probability densities which are found experimentally to be good models of many natural signals. We will briefly discuss the Gaussian and Exponential, (Fig. 3). Other amplitude probability densities such as the Poisson, Rayleigh, and rectangular are also important.

Gaussian (Normal) Amplitude Probability Density: The Gaussian is a particularly powerful amplitude probability density model. The Central Limit Theorem, indeed, states that the sum of n independent random variables will tend to have a Gaussian amplitude density as $n \to \infty$, no matter what may be the distributions of the original variables.

The Gaussian amplitude probability density function

$$p(x) = \frac{1}{\sigma\sqrt{2\pi}} \exp\left\{-\frac{1}{2}\left(\frac{x-\mu}{\sigma}\right)^2\right\} \tag{5}$$

and is shown in Fig. 3 for the zero-mean case. Actually, by redefining the variable as

$$t = \left(\frac{x-\mu}{\sigma}\right) \tag{6}$$

a normalized Gaussian independent of μ and σ is obtained, which is the one commonly tabulated. There is 68% probability of the Gaussian signal falling between $\mu \pm \sigma$; and 95% probability between $\mu \pm 2\sigma$, etc. The Gaussian also has the useful property that all higher moments are defined by the first two, μ and σ.

Fig. 4 shows a sample of the voltage history of a random noise generator used in analog computer work, which has a Gaussian distribution.

Exponential Amplitude Probability Density: The Exponential (Fig. 3) is,

$$p(x) = ae^{-ax} \tag{7}$$

It has only one parameter, a, and the first two moments are,

$$\mu = 1/a = \sigma \tag{8}$$

The exponential distribution is asymmetric about the mean, and the variable is limited to positive values.

Commonly the exponential is used to model the distribution of time durations of such phenomena as phone calls and servicing in gasoline stations, etc. Fig. 1(c) is a sample of such a phenomenon. We note now for further reference that the exponential amplitude probability density is really expressing the time (or frequency) characteristics of the signal rather than the amplitude characteristics. However, there are continuous signals also whose amplitude probability density function is like the exponential. For example,

(i) Rectified gust velocity;[14]

(ii) Variables in a non-linear closed-loop dynamic system.[7]

Some Engineering Examples Using the Probability Density Function

We will consider a few engineering applications using only the properties of probability density functions so far considered.

Extreme Value Statistics: In the design of almost all engineering systems, an economic balance must be obtained between the total capacity provided for the system and the utility of this extra capacity. Thus in all utility services (transit, electric, gas, communications) a very large capacity indeed would be needed to provide satisfactory capacity for the worst condition that might occur, and in general the utility of such extreme capacity does not justify its cost. In such cases the demand for service is a stochastic variable[6] and we are interested in the amplitude probability density in order to perform the appropriate economic calculations.

Similarly in design of structures, aircraft, ships and breakwaters, and heating plants, one needs to know the extreme values of environmental disturbances which may occur: wind and earthquakes, air turbulence, water waves, and ambient temperatures. The design of a protective system against freezing of the St. Lawrence Seaway[26] provides one fascinating and large-scale illustration of the statistical problem involved: namely, to obtain sufficient natural data over a sufficient range of time in order to be able to predict the probabilities of extreme values with some confidence; or alternatively to have sufficient confidence in an à priori theoretical model of the amplitude probability density to allow satisfactory prediction of extreme values.

As a hypothetical numerical example, consider that an earthquake could cause $\$10^9$ damage if some certain new buildings were to be destroyed. Assume that the "strengths" of 100 earthquakes at the site, with mean frequency of one per year, are available as an amplitude probability density, and that the maximum one recorded is 2σ beyond the mean value, μ. Design calculations show that each σ of extra protection beyond $\mu + 2\sigma$ costs $\$10^7$ (obviously a simplification!) Should one design against stronger earthquakes than $\mu + 2\sigma$, and if so by how much? Clearly the problem is not yet specified sufficiently. If the complete amplitude probability density of all earthquakes which have *and will ever* occur were known, then one could design for an economic minimum. This is not possible, but assuming for

numerical purposes that earthquake strengths have an exponential amplitude probability density (with $\mu = \sigma$) the following table shows that an economic minimum occurs by protecting against a maximum earthquake strength of about $\mu + 4\sigma$.

decisions in systems engineering can be very great;

(iv) *Human life* inevitably must be given a value in such analyses. This immediately takes the otherwise-engineering problem into the moral and sociological domain;

Earthquake "strength"	*Probability of occurrence per year*	*Expected earthquake loss per year*	*Extra cost of protection per year above $\mu + 2\sigma$*	*Total system cost*
Using Exponential distribution $\mu = \sigma$		$\$ \times 10^6$	$\$ \times 10^6$	$\$ \times 10^6$
$\mu + 2\sigma$	0.0498	49.8	—	49.8
$\mu + 3\sigma$	0.0183	18.3	10	28.3
$\mu + 4\sigma$	0.0067	6.7	20	26.7
$\mu + 5\sigma$	0.0025	2.5	30	32.5
$\mu + 6\sigma$	0.0009	0.9	40	40.9

The following points are worth noting:

(i) *Expected Loss.* The expected value of some function of a random variable is often needed. It is the product of the probability of occurrence and the cost (or pay-off) of the occurrence;

(ii) *The exponential amplitude probability density* model is of necessity invalid at some extremity of value, since nature can never produce infinite signals. Prediction beyond extreme values of the short sample usually available by using a best-fit theoretical amplitude probability density is therefore very uncertain;

(iii) *The monetary gain* from good

(v) Even if the engineer does not perform such an analysis, the insurance firm must do so to decide on the premium rate!

Functions of a Statistical Variable: In engineering systems one variable, y, often depends in some functional manner upon another variable, x, which is itself a random variable,

$$\left.\begin{array}{l}\text{i.e. } x = h(y) \\ \text{and } x(t) \text{ has an amplitude} \\ \qquad \text{probability} \\ \text{density, } p_1(x)\end{array}\right\} \quad (9)$$

An analytic technique is available to change the variable and obtain the new amplitude probability density, $p_2(y)$, (e.g. Ref. 8, p.213) from $p_1(x)$, i.e.

$$p_2(y) = p_1(f(y)) \cdot |f'(y)| \qquad (10)$$

In many cases the new amplitude probability density need not be calculated, but only some small number of parameters. Thus, as one example, we consider the case of bearing wear, in which the instantaneous wear rate is believed to vary as

$$y = bx^n \qquad (11)$$

where x is the instantaneous load.

From actual railroad records the amplitude probability density of x was found to be closely approximated by the Gaussian, with mean μ equal to the static weight, and r.m.s. deviation in the range, $0.1\mu < \sigma < 0.2\mu$. For engineering design we need to know the expected increased wear over the static case, or alternatively, the mean equivalent static load which produces the same total wear.

$$\bar{x} = (\bar{y}/b)^{1/n} \qquad (12)$$

Now the total wear Y in a time T is

$$Y = \int_0^T y(t)\,dt \qquad (13)$$

and the average wear rate is,

$$\bar{y} = \frac{1}{T}\int_0^T y(t)\,dt$$

$$= \frac{b}{T}\int_0^T \{x(t)\}^n\,dt \qquad (14)$$

Fig. 5. $\nu_n = (X)^n = n^{th}$ **moment about the origin**

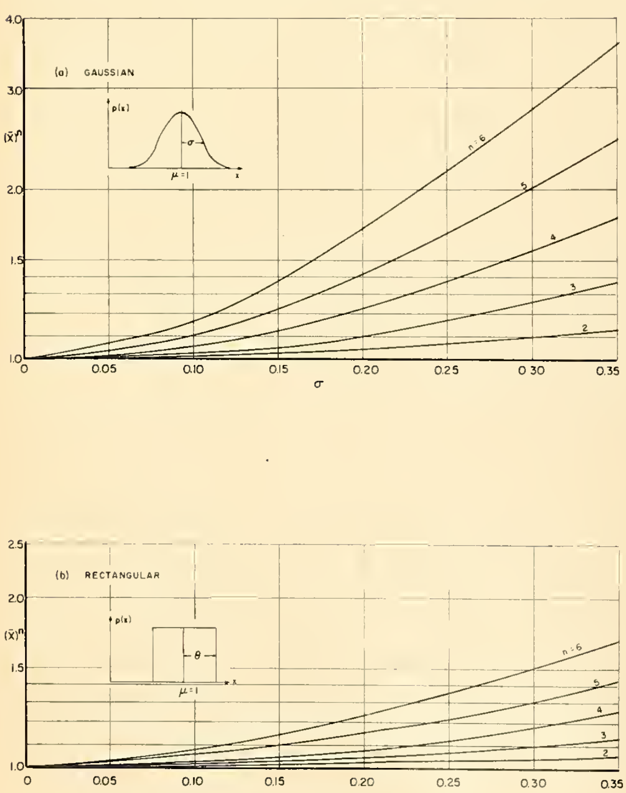
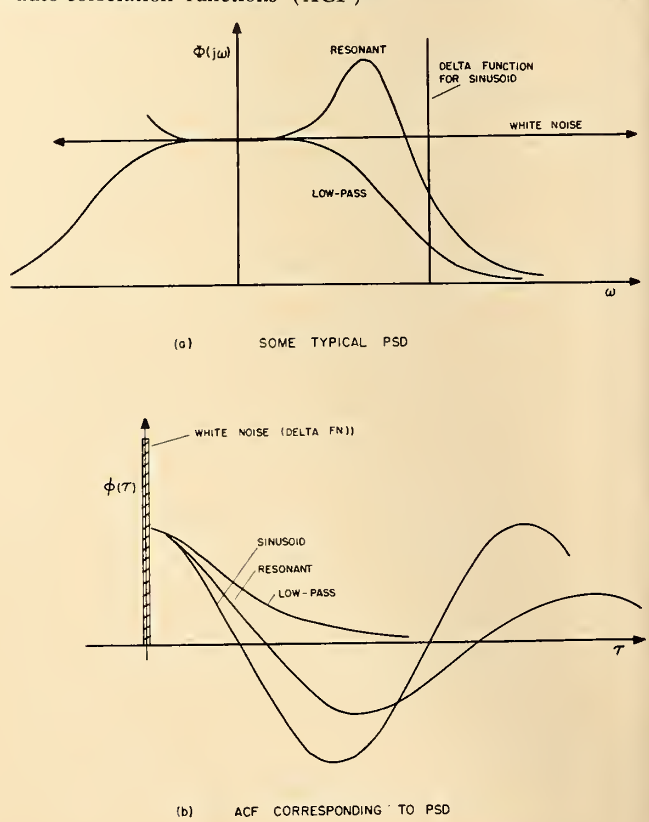


Fig. 6. Some typical power spectral densities (PSD) and auto-correlation functions (ACF)



But (dt/T) is the average proportion of time during which the instantaneous load is x, which from the definition of an amplitude probability density is also $p(x) \cdot dx$, i.e.

$$\frac{dt}{T} = p(x)\, dx \tag{15}$$

Substituting Eq. 15 in Eq. 14,

$$\bar{y} = b \int_{-\infty}^{+\infty} x^n p(x)\, dx \tag{16}$$

and from Eq. 2,

$$\bar{y} = b \cdot \nu_n(x) \tag{17}$$

and from Eq. 12,

$$\left.\begin{aligned} \bar{x} &= \{\nu_n(x)\}^{1/n} \\ (\bar{x})^n &= \nu_n(x) \end{aligned}\right\} \tag{18}$$

(Note that the limits of integration in Eq. 14 must be changed to integrate over the permissible amplitude range of the variable x; in fact, since the wheel jumps off the track for $x < 0$ we can in practice make the lower limit 0). Equations 18 show that the mean equivalent static load for an n-th law wear-load relation is defined by the n-th moment of the load amplitude probability density about the origin. These moments are tabulated;[9] and Fig. 5 presents a complete design chart for Gaussian and rectangular amplitude probability densities, for $2 < n < 6$, as functions of σ for the Gaussian, and of the semi-range θ for the rectangular. (Mean value of $x = \mu = 1$ has been assumed for convenience without loss of generality. The rectangular amplitude probability density is introduced for comparison only.)

Taking as a realistic numerical example, $n = 4$ and $\sigma = .15$ we find, for the Gaussian case, that

$$\left.\begin{aligned} (\bar{x})^4 &= 1.12 \\ \text{whence} \qquad (\bar{x}) &= 1.03 \end{aligned}\right\} \tag{19}$$

Thus the mean equivalent static load is increased 3% above the static load, and the wear is increased 12%.

Simulations and Monte Carlo Methods: Closed-form solutions are not possible in many engineering and industrial problems which include random effects. A simulated operation, by hand or computer, must then be made; however, due to the inclusion of random signals one run is generally not sufficient, and instead a series of runs must be made to evaluate average performance, r.m.s. error, extreme performance at both ends of the scale, etc. Problems of this type arise in engineering, industrial and office management, and military operations. The methods are variously called simulations, operational gaming, war gaming and Monte Carlo methods, and people of many disciplines attack such problems. Actually the definition, Monte Carlo method, is limited by some to the solution of a deterministic problem by using a physically-unrelated probabilistic model: by others, the repeated-run feature of solving a physical situation containing random signals.

One clear example of a probabilistic simulation requiring many runs is the evaluation of the kill probability of an airborne interceptor system. The basic equations to be solved are deterministic differential equations, but random noise arises at various points such as the radar link. A large number of runs must therefore be made to obtain a stable estimate of the kill probability, since clearly each individual run can only end in success or failure. The form of probability density function of the signals must be known, and indeed further information such as spectral density (to be discussed) may also be needed.

Another example is the simulation of breakdowns in a machine shop. If the probability density functions of both breakdown frequency and repair times are known from experimental data then a simulation may be performed to find the most economic maintenance staff, etc. Average waiting time for repair, utilization of staff, and other data can

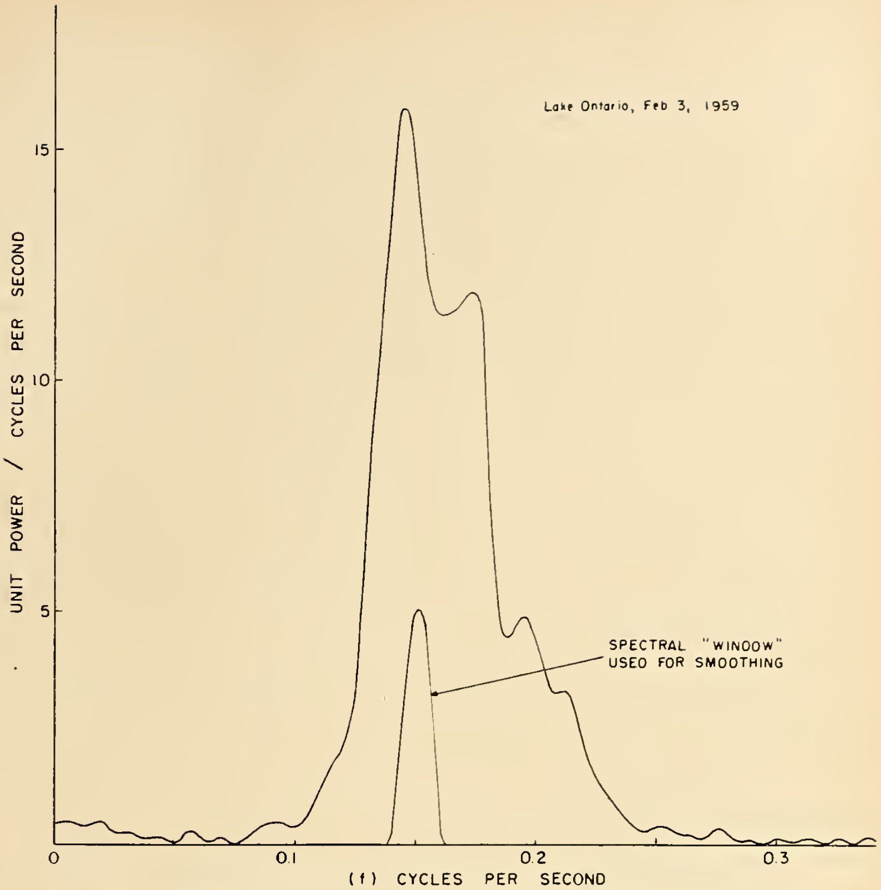


Fig. 7a. Normalized power spectral density for a pressure-wave-record[13]

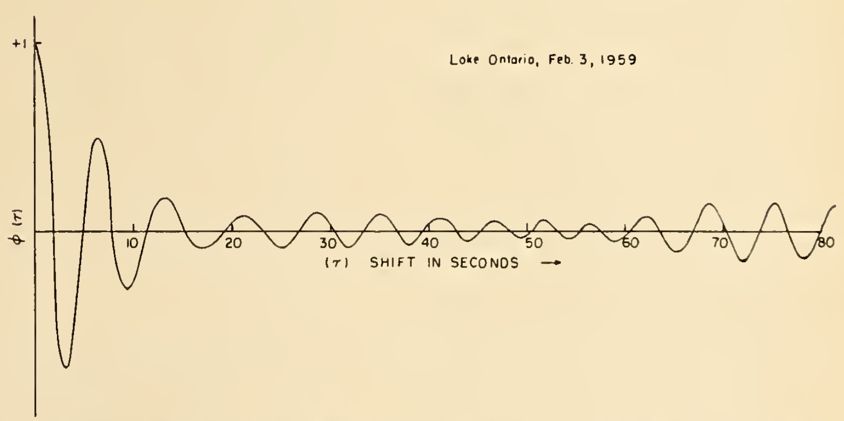


Fig. 7b. Normalized auto-correlation function computed for a pressure-wave-record[13]

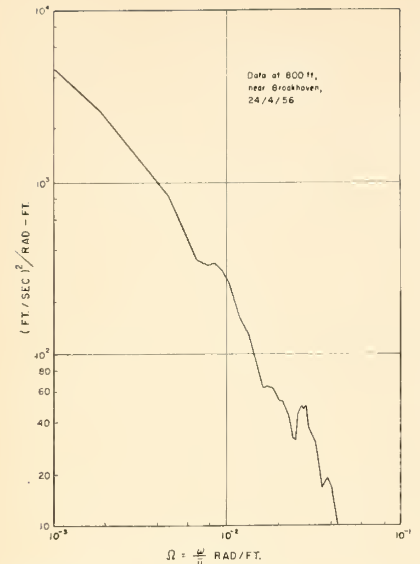


Fig. 8. Typical PSD of vertical gust velocity

all be predicted. This is one example from the general class of servicing problems referred to earlier and the engineer is interested in traffic flow, communications and maintenance type problems, to name only a few. One common difficulty is that sufficient data often does not exist to model the statistical variables accurately, and that data gathering is expensive.[5, 10, 11, 12]

Correlation and Spectra

Power Spectral Density (Φ): As is well known to engineers, a periodic signal may be considered mathematically as a Fourier series with fundamental frequency and discrete harmonics. In an aperiodic signal, such as a random variable, this discrete spectrum becomes continuous because the fundamental frequency is zero (the period of repeatability becomes infinite). The resulting power spectral density ($\Phi(j\omega)$) therefore describes the distribution of power along the frequency axis. The total "power" of a random variable in the mean square sense, is given by the integral of $\Phi(j\omega)$,

$$\overline{x(t)^2} = \frac{1}{2\pi}\int_{-\infty}^{+\infty} \Phi(j\omega)\, d\omega \qquad (20)$$

We note that Φ is an even function of frequency,

$$\Phi(j\omega) = \Phi(-j\omega) \qquad (21)$$

"White" noise is a conceptual signal with constant spectral density out to infinite frequencies. Eq. (20) shows that its power would be infinite also, and it is indeed not physically realizable.

Fig. 6(a) shows some spectra which frequently arise including the "low-pass" and "resonant". Because the power spectral density is a density function no finite power is present at any one frequency. Therefore if the variable comprises both a random signal and a sinusoidal one, then the sinusoid produces a Dirac delta function at the appropriate frequency of strength equal to the mean square value. Fig. 7(a) shows the highly-resonant power spectral density obtained experimentally from a water-wave record in Lake Ontario.[13] We shall return later to the "spectral window" characteristic shown on the same figure. Fig. 8 shows the power spectral density of measured vertical air gusts[14] over Brookhaven, and it is "low-pass".

It is important to realize that the power spectral density is an independent measure from the amplitude probability density previously discussed. It is however the Fourier transform of another important measure, the auto-correlation function, which we now discuss.

Auto-correlation Function (ϕ): In the time domain the auto-correlation function measures how well the function correlates with itself when shifted in time:

$$\left.\begin{aligned}\phi(\tau) &= \overline{x(t)x(t+\tau)}\\ &= \lim_{T_n\to\infty}\frac{1}{T_n}\int_0^{T_n} x(t)x(t+\tau)\,dt\end{aligned}\right\} \qquad (22)$$

Clearly the correlation, or averaged product, for zero timeshift is the mean square value, and, also clearly, this value cannot be exceeded, i.e.

$$\phi(0) = \overline{x(t)^2} \qquad (23)$$

$$\text{and } \phi(0) \geq \phi(\tau), \qquad \tau > 0 \qquad (24)$$

Also we have,

$$\phi(\tau) = \phi(-\tau) \qquad (25)$$

The auto-correlation function and power spectral density are not independent measures, but constitute a Fourier transform pair;

$$\Phi(j\omega) = \int_{-\infty}^{+\infty}\phi(\tau)e^{-j\omega\tau}d\tau \qquad (26)$$

$$\phi(\tau) = \frac{1}{2\pi}\int_{-\infty}^{+\infty}\Phi(j\omega)e^{+j\omega\tau}d\omega \qquad (27)$$

Fig. 6(b) shows the auto-correlation functions corresponding to the spectra

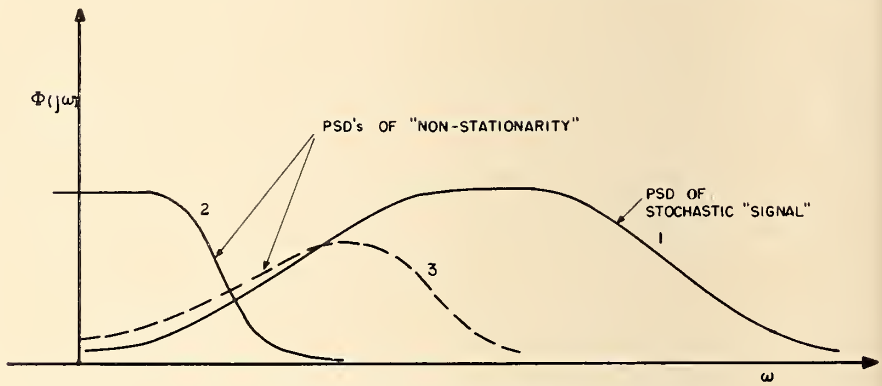
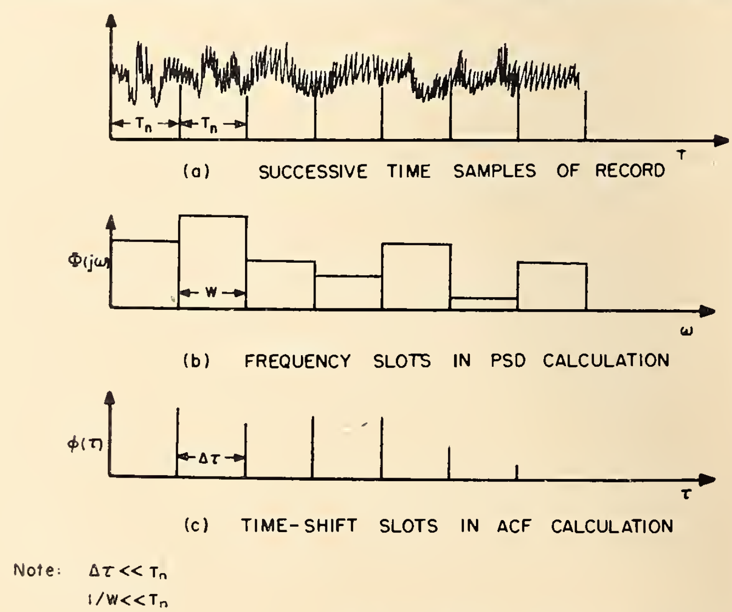


Fig. 9. (Top) Power spectral density components

Fig. 10. (Bottom) Power spectral density and auto-correlation function components



of Fig. 6(a). We note that a white spectrum is equivalent to a delta function in $\phi(\tau)$; the sinusoid in time becomes a sinusoid in auto-correlation function also. As one practical example, Fig. 7(b) shows the auto-correlation function from the water-wave record, and the resonant feature is clearly visible.

In principle the auto-correlation function and power spectral density carry the same information and therefore we need use only one measure. However, engineers often prefer to use both since their characteristics tend to be complementary for human comprehension.

Computation, Stationarity and Confidence: We ask what is the effect of using the short record length, T_n, which will be necessary because; (i) obtaining and processing records is expensive, (ii) the stochastic signal may not be stationary.

Stationarity

As already mentioned a signal is stationary if the statistical measures are not time-dependent. In general the engineers' world is non-stationary, although fortunately it may often be considered stationary for sufficient lengths of time. Thus as a machine-tool cutter wears there will be a drift on the scatter-plot which constitutes a quality-control chart of the products' size. This drift is readily appreciated as a non-stationarity of an otherwise stochastic variable. Similarly the spectrum of vibration from a rocket will vary considerably in time as the propellant is burned causing changes in natural frequencies and modes. These are cases of fairly determinate non-stationarities, and in performing computations to find the power spectral density or auto-correlation function, one might well remove the drift from the data beforehand, or take a short-enough record that the effect of the non-stationarity is small. In general, however, a non-stationarity may also be stochastic. In this case, a plot of respective power spectral densities indicates our possibilities and limitations (Fig. 9). Thus the non-stationarity of curve (2) can largely be separated out from our signal (curve (1)), whereas curve (3) cannot; this really is a filtering problem, which is discussed later.

Computation

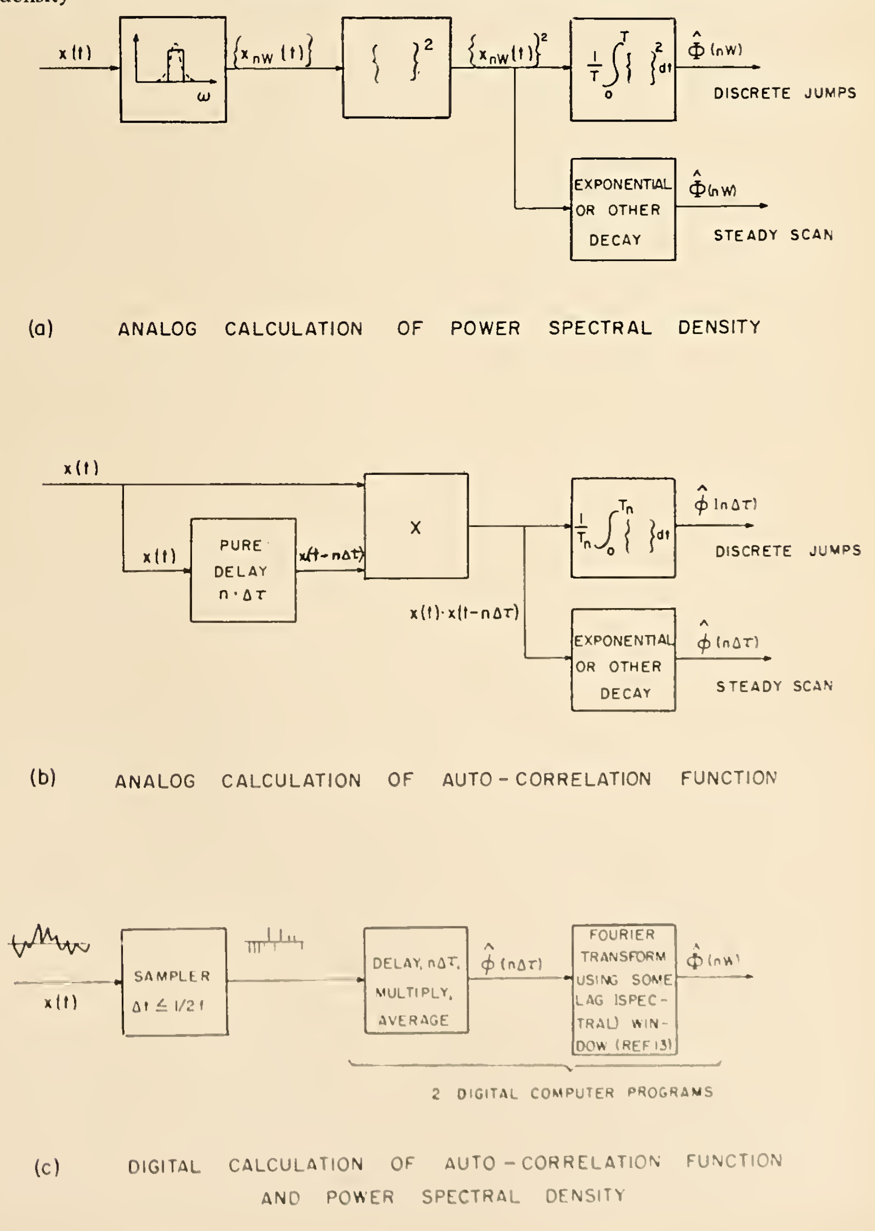
Direct calculation of the power spectral density and auto-correlation function is possible by analog techniques from experimental (analog) data. Usually the result is built up as a histogram from a set of elementary calculations. Each frequency slot (W, Fig. 10(b)) or time shift increment ($\Delta\tau$, Fig. 10(c)) must be calculated as the average result of a sufficiently long sample of signal, T_n(where $T_n \gg 1/W$ and $T_n \gg \Delta\tau$—see below). If the signal is confidently believed to be stationary then successive samples of record (T_n, Fig. 10(a)) may be used to calculate the successive slots (either of frequency or time shift) without loss of statistical confidence in the result. If the signal is non-stationary, either parallel calculation paths must be available, or the sample must be recorded so that it can be successively cycled through the unit computation for the required number of slots. Parallel calculation paths are quite possible but are expensive in equipment.

When the power spectral density is measured directly by analog means, the frequency slot, W, is approximated by a tuned filter of narrow bandwidth, and either its natural frequency is altered or a modulation technique is used to shift the spectrum past a constant frequency-slot filter.[15–17] Further, the slot frequency may be changed either in discrete jumps or in a steady scan, (Fig. 11(a)). The resulting power spectral density is only an estimator of the true one and hence the modified symbol, $\hat{\Phi}$, is used. We note that some theoretical problems are introduced by continuous scan.

When the auto-correlation function is computed directly an averaged product must be obtained of the function, $x(t)$, and itself shifted in time, $x(t - \tau)$. This is instrumented by analog means as shown in Fig. 11(b). Again either discrete jumps ($\Delta\tau$) or a steady scan in time shift may be made. By use of a digital time delay, as with a digital machine coupled to an analog computer, multiple delays can be conveniently obtained and hence a large number of averaged products may be obtained simultaneously.[18] The steady scan technique is not widely used.

Finally there is the digital method of calculation which is most popular to-

Fig. 11. Methods of calculation of auto-correlation function and power spectral density



day, although it is not necessarily most economic. The continuous record $x(t)$ must be sampled and recorded suitably for input to a digital computer. A minimum sampling interval, Δt, is determined from the Shannon sampling theorem as,

$$\Delta t \leq 1/2f \tag{28}$$

where f = maximum frequency (in c.p.s.) present in $x(t)$. Since the signal bandwidth is likely unknown until the calculation is performed, a conservative estimate must be made. The digital computer program most economically determines the auto-correlation function estimate first, and then performs the Fourier transformation to estimate the power spectral density (Fig. 11(c)). Ref. 18 compares the time involved in digital, analog and combined methods in more detail.

In all methods a finite record length, T_n, only is used. Further in the digital power spectral density calculation a finite length of auto-correlation function only is used in the Fourier transformation, and the particular results obtained are analysed in terms of the "lag window" used, or its corresponding "spectral" window. Fig. 7(a) shows the spectral window used in that particular digital computation, and its inclusion indicates the resolution to be expected in the power spectral density. These considerations are discussed in more detail in Ref. 13. In general the finite length of the calculations raises the problem of statistical variability in the estimator which results—i.e. the auto-correlation function and power spectral density estimators are themselves statistical variables which estimate the true value with some confidence.

Confidence and Record Length

This subject is quite complicated and only a brief comment is made here.[13,15] In power spectral density measurement, the elementary slots, W, represent the *resolution* achieved. In general a trade-off exists between the *resolution* and *record length*, T_n, for a given *confidence* in the estimates so obtained. The confidence measure derives from the *degrees of freedom*, k, measure of a Chi-squared (χ^2) distribution, where each frequency slot is considered an independent estimate contributing two degrees of freedom.

$$\left.\begin{array}{ll}\text{Thus} & k \propto W \cdot T_n, \\ \text{and usually we take} & \\ & k = 2WT_n\end{array}\right\} \tag{29}$$

Fig. 12[13] shows the 90% confidence region in the estimator, $\hat{\Phi}$, as a function of k. 90% is a typically-acceptable engineering confidence, but other percentage curves could easily be used if desired. The resulting requirement on record length often seems severe at first acquaintance. Thus for a 1 c.p.s. resolution, which might be required in a 20 c.p.s. bandwidth signal for example, 10 seconds of this signal would be required for $k = 20$. Then the ratio of $\hat{\Phi}$ to $\hat{\Phi}_{av}$ would still only lie within .55 and 1.57 90% of the time—i.e. there is still a very significant variability.

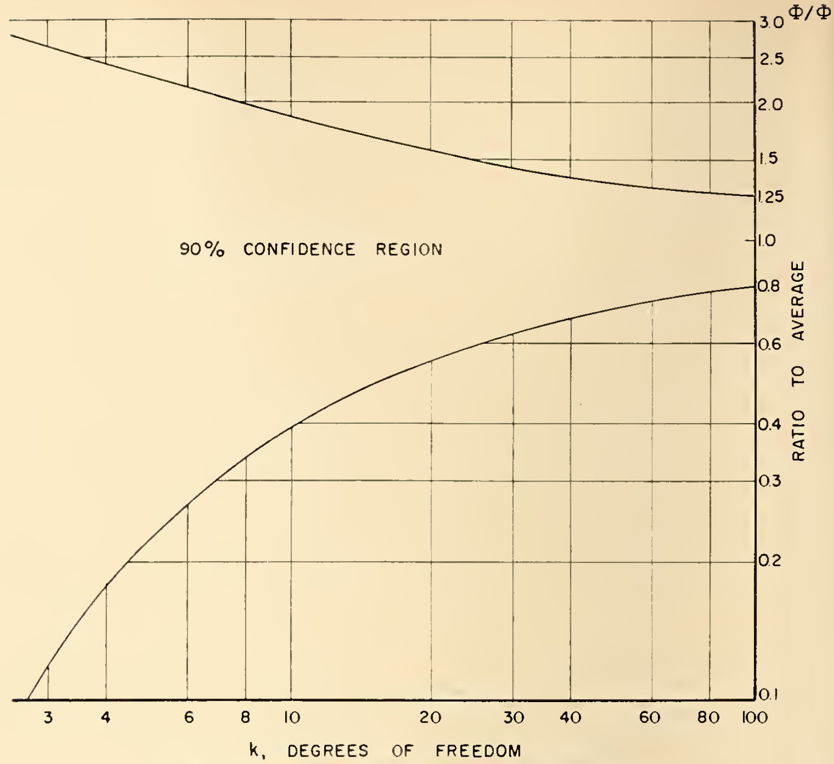


Fig. 12. 90% limits of the chi-square distribution

An older and simpler rule was that the record length should be at least 10 times the reciprocal of the lowest frequency significantly present. This rule, however, is inadequate if the spectrum has components near zero frequency; and furthermore, no confidence estimate is possible.

It is interesting to note that it may be impossible to measure the power spectral density of certain finite-duration signals with satisfactory confidence. For example, the duration of earthquakes is of the order 10 sec. and hence a resolution of order 1 c.p.s. could possibly be obtained (as shown by the above calculation). However, from à priori knowledge, it seems unlikely that earthquakes are stationary. In fact, the present situation is complicated by the fact that people in this particular discipline use a dynamic filtering combined with extreme value measurement to specify their "spectra".[6]

Linear Filtering

Analytic Relations: The input-output relation for a system described by a set of linear differential equations (linear transfer function) is defined, (Fig. 13(a)),

(i) in the time domain by the convolution integral,

$$o(t) = \int_0^t i(y)g(t-y)\,dy = i(t)*g(t) \tag{30}$$

where $i(t)$, $o(t)$ are the input and output variables, y is a dummy variable of integration, $g(t)$ is the impulse response of the system, i.e., the output when a unit impulse is inputted at $t = 0$, Fig. 13(b);

(ii) in the complex frequency domain (s), by

$$O(s) = G(s)I(s) \tag{31}$$

where $O(s)$ etc. are the respective Laplace transforms of $o(t)$ etc., viz,

$$O(s) = \int_0^\infty o(t)e^{-st}\,dt \tag{32}$$

When we consider sinusoidal oscillations only, $s = j\omega$, and $G(j\omega)$ is the frequency response of the system.

For stochastic variables with Gaussian amplitude probability density there are analogous relations which allow us to work with the few measures already discussed;

(i) in the time domain (correlation functions),

$$\phi_{i0}(\tau) = \int_0^\tau \phi_{ii}(y)\cdot g(\tau-y)\,dy \tag{33}$$

where ϕ_{i0} = cross-correlation function of $i(t)$ and $o(t)$,

$$= \overline{i(t-\tau)o(t)} \tag{34}$$

(ii) in the frequency domain (spectra),

$$\Phi_{00}(j\omega) = \Phi_{ii}(j\omega)\,|\,G(j\omega)\,|^2 \tag{35}$$

$$\Phi_{0i}(j\omega) = \Phi_{ii}(j\omega)\cdot G(j\omega) \tag{36}$$

where $\Phi_{0i}(j\omega)$ is the cross spectral density of $i(t)$ and $o(t)$.

Eq. (35) describes the effect of linear filtering upon power-spectral-density amplitudes only, whereas Eq. (36) provides information on both amplitude and phase. In principle the phase characteristic is not needed in the treatment of a wide class of engineering systems if the amplitude characteristic is known. Hence the phase relation is usually omitted.

Mean Square Signals After Filtering: Eq. (20 and 35) indicate that the mean square value of a signal of spectrum $\Phi(j\omega)$, after linear filtering by $G(j\omega)$ is,

$$\left.\begin{aligned}\overline{x(t)^2} &= 1/2\pi \int_{-\infty}^{+\infty} \Phi(j\omega) \mid G(j\omega) \mid^2 d\omega \\ &= I_n\end{aligned}\right\} \tag{37}$$

Special tables of integrals are available[19] to evaluate this integral, I_n, for polynominal spectra and filters to the 10th power in the denominator (and 9th in the numerator).

As an example, assume that in an experiment we want to approximate white noise, Φ_w, by a first-order lag spectrum (of break frequency $1/T_s$). This signal is then to pass through a system described by a first-order lag, T_f, and we want to know how small T_s must be to keep the m.s. output within $k\%$ of that which would exist if the noise were ideally white.

For the white spectrum, Φ_w = constant, and the filtered output is given by,

$$\begin{aligned}\overline{x_1(t)^2} &= \frac{1}{2\pi}\int_{-\infty}^{+\infty} \Phi_w \left| \frac{1}{1 + j\omega T_f} \right|^2 d\omega \\ &= \Phi_w \cdot I_1 \\ &= \Phi_w/2T_f \end{aligned} \tag{38}$$

where I_1 is obtained from the table in Ref. 19.

For the first-order lag spectrum,

$$\begin{aligned}\overline{x_2(t)^2} &= \frac{1}{2\pi}\int_{-\infty}^{+\infty} \Phi_w \left| \frac{1}{(1+j\omega T_f)(1+j\omega T_s)} \right|^2 \\ &= \Phi_w \cdot I_2 \\ &= \frac{\Phi_w}{2(T_f + T_s)}\end{aligned} \tag{39}$$

$$k = \frac{\overline{x_1^2} - \overline{x_2^2}}{\overline{x_1^2}} \cdot 100 = \frac{T_s}{T_f + T_s} \cdot 100 \tag{40}$$

This example indicates the procedure, although in practice it represents a rather trivial problem.

As a practical example, Fig. 13(c) shows a low-pass filter operating on a resonant spectrum to "whiten" it out to as high a frequency as possible. This filtering is actually performed in a standard low-frequency random noise generator for analog computer work.

Optimal (Open-loop) Filtering: Optimal open-loop filtering arises in many straight-through communication and power channels. One standard problem concerns the optimum separation of a stochastic signal from stochastic noise, i.e., we want to pass, and often modify also, the signal, but eliminate the noise. Wiener and Kolmogoroff originally developed optimum filtering theory some 20 years ago, and much further development has since occurred. The following summary largely follows Truxal:[20]

The input, $i(t)$, to a system, $G(s)$, (Fig. 14) consists of signal, $s(t)$, and noise, $n(t)$, both of which may be random. It is desired that a certain system function, $G_d(s)$, operate upon the signal, $s(t)$, to produce $y_d(t)$. There is an error $e(t)$ between $y_d(t)$ and the actual output, $y_a(t)$, which it is desired to minimize. The following assumptions are made:

(i) The systems G and G_d are linear;

(ii) The signals are stationary and Gaussian;

(iii) The noise and signal are uncorrelated. (This is normally true, but if not, the cross correlation term must be included);

(iv) A satisfactory criterion of optimality is minimization of the mean square error;

(v) Spectral densities of the signal and noise (Φ_s and Φ_n) are known quantities. (Similar time domain techniques exist using correlation functions.)

The mean square error can be shown to be

$$\overline{e^2} = \frac{1}{2\pi}\int_{-\infty}^{+\infty} \left[\Phi_n(j\omega) \cdot \left| G(j\omega) \right|^2 + \Phi_s(j\omega) \left| G_d(j\omega) - G(j\omega) \right|^2\right] d\omega \tag{41}$$

and consists of two components,

(i) incomplete filtering of the noise, Φ_n,

(ii) imperfect filtering of the signal, Φ_s, by G instead of G_d.

A simple development produces a specification for $G(s)$ which minimizes the mean square error but which is generally not physically realizable because the impulse response is required to be non-zero for $t < 0$, i.e., the system must respond before it is excited. An artificial technique of splitting $G(s)$ conceptually is then used to obtain the physically-realizable optimal filter.

Thus $$G(s) = G_1(s) \cdot G_2(s) \tag{42}$$

firstly, $$G_1(s) = \frac{1}{\Phi_i^+(s)} \tag{43}$$

where

$$\begin{aligned}\Phi_i(s) &= \Phi_n(s) + \Phi_s(s) \\ &= \Phi_i^+(s) \cdot \Phi_i^-(s)\end{aligned} \tag{44}$$

Φ_i^+ indicates that part of Φ_i with left-half plane poles and zeros only, and Φ_i^- the right-half plane parts. $G_i(s)$ is in fact a realizable filter which converts $\Phi_i(s)$ to white noise.

Secondly,

$$\left.\begin{aligned}G_2(s) &= \{G_2^*(s)\}_{\text{realizable}} \\ &= \left\{\frac{\Phi_s(s)}{\Phi_i^-(s)} \cdot G_d(s)\right\}_{\text{realizable}}\end{aligned}\right\} \tag{45}$$

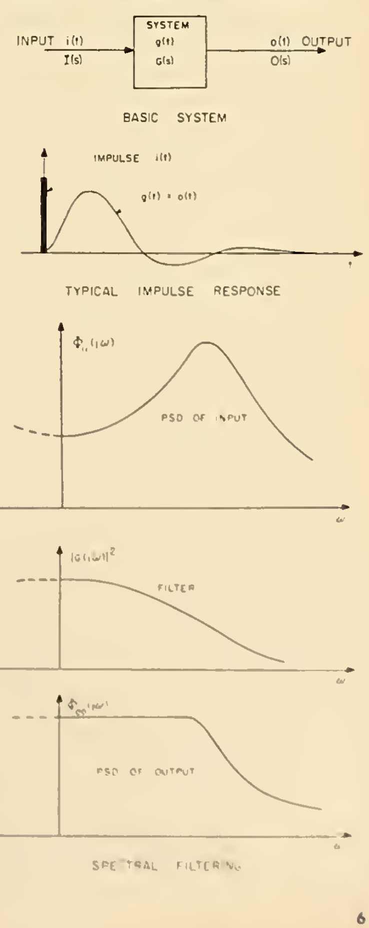
In general, the filter $G_2^*(s)$ within the brace on the right-hand side is not physically realizable. The technique is therefore to obtain a $G_2(s)$ whose time domain impulse response omits that part of the impulse response of $G_2^*(s)$ which exists for negative time. The design technique uses Laplace transformation to effect this.[20]

The complete filter is now,

$$\begin{aligned}G(s) &= G_1(s) \cdot G_2(s) \\ &= \frac{1}{\Phi_i^+(s)}\left\{\frac{\Phi_s(s)}{\Phi_i^-(s)} \cdot G_d(s)\right\}_{\text{realizable}}\end{aligned} \tag{46}$$

As a simple example we consider the case of filtering a noise from a signal when both have have "first-order lag" spectra, for example, a spectrum pro-

Fig. 13. Input-output relations



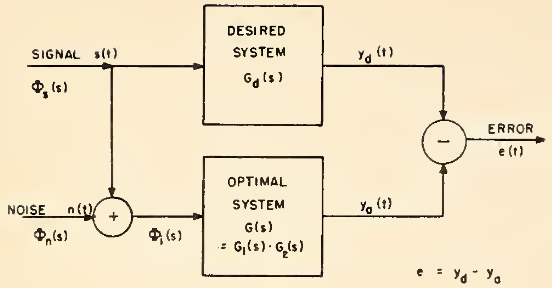


Fig. 14. The linear filtering problem

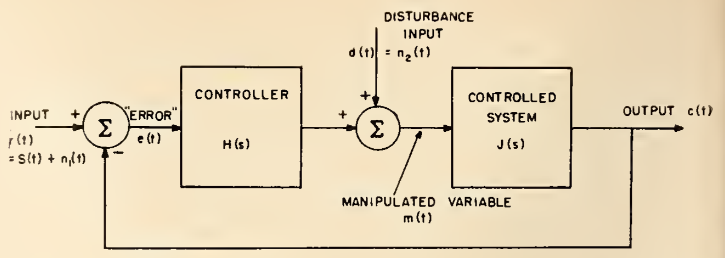


Fig. 15. Basic closed-loop control system

duced by passing white noise through a first-order lag, $1/(1 + Ts)$. In practice typical desired filtering operations, G_d, are predictions or delays, and we specify a unity-gain operator only to make the example simple.

We have

$$\left.\begin{aligned} \Phi_s(s) &= \frac{1}{1-(Ts)^2}, \\ \Phi_n(s) &= \frac{\beta}{1-(\alpha Ts)^2}, \\ G_d(s) &= 1 \end{aligned}\right\} \quad (47)$$

therefore

$$\Phi_i(s) = \frac{(1+\beta)[1-(\delta Ts)^2]}{[1-(Ts)^2][1-(\alpha Ts)^2]}$$

where

$$\delta^2 = \frac{\alpha^2 + \beta}{1+\beta}$$

therefore

$$G_1(s) = \frac{(1+Ts)(1+\alpha Ts)}{\sqrt{1+\beta}(1+\delta Ts)}$$

$$G_2{}^*(s) = \frac{(1-\alpha Ts)}{\sqrt{1+\beta}(1+Ts)(1-\delta Ts)}$$

$$G_2(s) = \frac{(1+\alpha)}{\sqrt{1+\beta}(1+\delta)} \frac{1}{1+Ts}$$

therefore

$$G(s) = \frac{(1+\alpha)}{(1+\beta)(1+\delta)}\left(\frac{1+\alpha Ts}{1+\delta Ts}\right) \quad (48)$$

Three special cases give some insight into this relation,

(i) No noise, i.e., $\beta = 0$

$$\delta = \alpha, \quad G(s) = 1 \quad (49)$$

(ii) Noise and signal spectra identical, i.e., $\alpha = 1 = \beta$

$$\delta = 1 \quad \text{and} \quad G(s) = 1/2 \quad (50)$$

(iii) Noise of infinite bandwidth, $\alpha \to 0$, $\beta = 1$,

therefore $\delta = 0.707$

$$G(s) = \frac{1}{3.414(1+0.707Ts)} \quad (51)$$

The filter's break frequency is therefore somewhat greater than the signal's break frequency, and the output spectrum is distorted from that of the original signal spectrum. The output spectrum of course can be written down from Eqs. (47), (51) and (35), and the mean square error can be evaluated.

The optimal-filtering relations have been developed for a completely free hardware configuration; that is, design would ideally consist of (i) specification, (ii) filter calculations as above, and (iii) realizing the filter in hardware. In practice we often wish to optimize a situation in which all or part of the hardware is already specified, and only parameters of the system may be adjusted. This happens frequently in closed-loop control systems, which we now mention.

Closed-loop Filtering: Closed-loop control systems have the generalized configuration of Fig. 15, although many are multi-variable, rather than the simple one-variable case shown. In servomechanisms the purpose is to have the output $c(t)$ track the reference input $r(t)$, usually with considerable power-level amplification. In regulators the reference signal is usually fixed and we ask for constant output in the presence of disturbance signals. Disturbance signals in both types arise as; (i) noise in the reference signal, $[r(t) = s(t) + n_1(t)]$; (ii) random or determinate disturbance signals $[d(t) = n_2(t)]$; (iii) signals generated by time-varying transfer functions. Since $J(s)$ is a controlled system its configuration is often fixed and the controller $H(s)$ is the unit whose transfer function or parameters can be most easily adjusted for optimization. (We do not further consider the non-stationary effect (iii).)

Optimal linear filtering techniques are easily extended to the closed-loop case, again using the minimum mean square error criterion.[20] However, this is only partial optimization because the operating costs of obtaining a minimum mean square error may far exceed the value so derived. An attempt at extending the mean square error criterion for economic optimization of closed loops has been made by the author, among others.[7]

Here we only state the method of obtaining the modified mean square error expression for Eq. (41). Again, linearity is essential. Both $n_1(t)$ and $n_2(t)$ produce outputs at $c(t)$ which can be computed separately provided they are uncorrelated, by using the appropriate closed-loop transfer relations.[20] Since these noises are disturbances, any resulting output is an error.

Thus the error spectral density, Φ_{c_n}, at the output c, due to the noise spectra Φ_{n_1} and Φ_{n_2} is

$$\Phi_{c_n} = \left|\frac{C}{R}\right|^2 \cdot \Phi_{n_1} + \left|\frac{C}{D}\right|^2 \cdot \Phi_{n_2} \quad (52)$$

(where the variable s or $j\omega$ is now being omitted for simplification).

The desired transfer function G_d on the signal $s(t)$ from $r(t)$ to $c(t)$ is,

$$G_d = 1 \quad (53)$$

whereas the achieved G is,

$$G = \frac{C}{R} = \frac{HJ}{1+HJ} \quad (54)$$

Therefore the error transfer function for imperfect transmission of signal is,

$$G_d - G = 1 - \frac{C}{R} = \frac{E}{R} \quad (55)$$

i.e. the transfer function from $r(t)$ to $e(t)$. The error spectral density at the error point due to the signal, Φ_s, is

$$\Phi_{c_s} = \left|\frac{E}{R}\right|^2 \cdot \Phi_s \quad (56)$$

Thus Eq. (41) becomes

$$MSE = \frac{1}{2\pi}\int_{-\infty}^{+\infty} \left[\left|\frac{C}{R}\right|^2 \cdot \Phi_{n_1} + \left|\frac{C}{D}\right|^2 \cdot \Phi_{n_2} + \left|\frac{E}{R}\right|^2 \Phi_s\right] d\omega \quad (57)$$

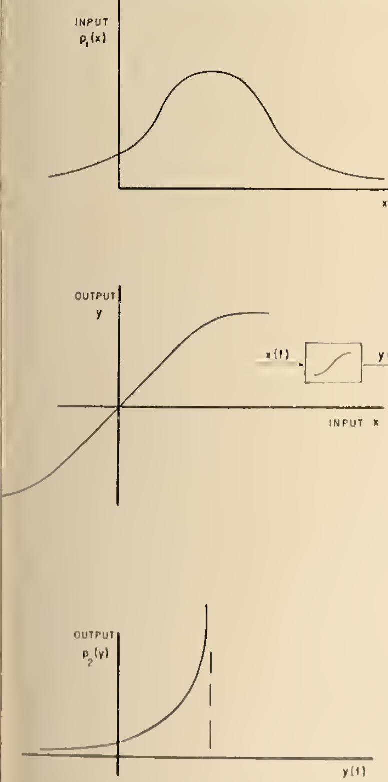
If a physical system is now taken with k adjustable parameters, such as controller gain for a $k = 1$ example, the mean square error can be minimized by equating the partial derivatives to zero, i.e.,

$$\frac{\partial(MSE)}{\partial k_j}\Bigg]_{j=1}^{n} = 0 \qquad (58)$$

Non-Linearity

A static non-linearity such as the common saturation effect clearly changes the amplitude probability density of a signal (Fig. 16). In reverse, therefore, any arbitrary amplitude probability density transformations may be made by appropriate use of a static non-linearity.[21] However, a static non-linearity also changes the power spectral density, and the power spectral density filtering relation already developed, using linear systems, cannot be used to reshape the power spectral density since it only applies for Gaussian amplitude probability density signals. (However, the power spectral density or auto-correlation function can be computed for a Gaussian input across a static non-linearity.[4]) In fact, the Central Limit Theorem is generally taken to assert that linear filtering tends to restore any amplitude probability density to the Gaussian.[22] However, Ref. 23 shows that this is not always true, by giving an example of wide-band noise with a sinusoid. Thus amplitude probability density and power spectral density changes by filtering are generally inter-coupled, and this subject is not analytically well documented.

Fig. 16. Non-linear filtering of amplitude probability density



These problems arise in striking fashion in non-linear, closed-loop control systems subject to random inputs. At present the technique of statistical linearization is available[24,25] to predict the mean square error for such systems with reasonable accuracy. This technique assumes that the linear portion of the control-loop returns signals closely to the Gaussian amplitude probability density at the error point, after distortion therefrom in the static non-linearity. This cannot, and is not, of course completely true, but predictions of the mean square error criterion are quite tolerant to departures from Gaussian amplitude probability density. Calculations become quite complicated, however, and often involve interative methods of solution. The author has attempted to optimize non-linear control systems based upon economic criteria[7] using the sum of (i) "non-linear" error costs and (ii) operating costs derived from manipulated varibles (Fig. 15). Prediction of the non-linear error function was found to be unsatisfactory if one assumed that the error signal was Gaussian (which indeed it was not, as confirmed by the measurements reported above).

Thus, there are wide gaps in our knowledge for dealing with stochastic signals in non-linear systems, but much research is being done in this field.

Summary

Most natural signals affecting engineering systems are stochastic and this has greatly affected engineering design procedures in recent years. In addition randomness is generated within systems themselves. Difficult problems are added when non-linear systems are used, especially if they are of closed-loop form. The increasing treatment of stochastic variables in engineering design is partly due to the recent availability of electronic computers to perform tedious calculations and simulations.

The two measures essential to describe stochastic variables are defined, namely:

(i) the probability density function,

(ii) the power spectral density, or alternatively the auto-correlation function.

Engineering examples of these measures are given and some theoretical models are presented. Stationarity, resolution, record length and confidence are introduced in discussing methods of computing the second measure. Linear filtering is discussed, including optimal realizable filtering. Extreme value statistics and functions of a statistical variable are also mentioned. Many simple practical examples are given to illustrate results and techniques, and much further reading is suggested.

References

1. Bendat, J. S. Principles and Applications of Random Noise Theory, J. Wiley and Sons.
2. Davenport, W. B. Jr., Root, W. L. An Introduction to the Theory of Random Signals and Noise, McGraw Hill Book Co., 1958.
3. Crandall, S. H., et al Random Vibration, Technology Press MIT, 1958.
4. Laning, J. H. Jr., Battin, R. H. Random Processes in Automatic Control, McGraw Hill Book Co., 1956.
5. Bowman, E. H., Fetter, R. B. Analysis for Production Management, R. D. Irwin Inc., Homewood, Illinois, 1957.
6. Milsum, J. H. Random Signals in Engineering Systems, DME/NAE Quarterly Bulletin 1960(1), National Research Council, Ottawa, May 1960.
7. Milsum, J. H. Statistical Optimization of Regulators Employing a Binary Error Criterion, ASME 58-A-71, July 1958.
8. Hoel, P. G. Introduction to Mathematical Statistics, J. Wiley and Sons, 1954.
9. Burington, R. S., May, D. C. Handbook of Probability and Statistics with Tables, Handbook Publishers Inc., Sandusky, Ohio, 1953.
10. Goode, H. H., Machol, R. E. System Engineering, McGraw Hill, 1957.
11. Beckenbach, E. F., et al Modern Mathematics for the Engineer, McGraw Hill Book Co., 1956.
12. Grabbe, E. M., Ramo, S., Wooldridge, D. E. Handbook of Automation, Computation and Control, Vol 1 (and 3, to come), J. Wiley and Sons, 1958.
13. Funke, E. R. R. Correlation Function and Power Spectral Density Analysis, Paper presented to ASCE, Boston 1960. (Available from Analysis Section, Div. of Mech. Eng'g., N.R.C.).
14. Lappe, V., Davidson, B., Notess, C. B. Analysis of Atmospheric Turbulence Spectra Obtained from Concurrent Airplane and Tower Measurements, IAS Rept. 59-44, Jan. 1959.
15. Blackman, Tukey The Measurement of Power Spectra, Dover Publications, 1959.
16. Wonnacott, T. H. Direct Measurement of Power Spectra by an Analog Computer, N.R.C. Rept. MK-5, Sept. 1959.
17. Smith, F. B. Analog Equipment for Processing Randomly Fluctuating Data, NACA Preprint IAS 545, Jan. 1955.
18. Baxter, D. C., Milsum, J. H. Requirements for a Hybrid Analog-Digital Computer, ASME 59-A-304, 1959.
19. Newton, G. C., Gould, L. A., Kaiser, J. F. Analytical Design of Linear Feedback Controls, J. Wiley and Sons, 1957.
20. Truxal, J. G. Automatic Feedback Control System Synthesis, McGraw Hill Book Co., 1955.
21. Vander Veld, W. E. Make Statistical Studies on Analog Simultations, Control Engineering, 1960.
22. Mazelsky, B. Extension of Power Spectral Methods of Generalized Harmonic Analysis to Determine Non-Gaussian Probability Functions of Random Input Disturbances and Output Responses of Linear Systems, Jr. of the Aeronautical Sciences, Vol. 21 No. 3, pp. 145-153, March 1954.
23. Crandall, S. H., Siebert, W. H., Hoquetis, B. P. The Response of Linear Systems to Non-Gaussian Random Inputs, Jr. of the Aero/Space Sciences, pp. 154-155, Feb. 1960.
24. Kazakov, I. E. Approximate Probability Analysis of the Operational Precision of Essentially Non-linear Feedback Control Systems, Automatyki i Telemekaniki, Moscow, USSR 1955.
25. Booton, R. C. Non-linear Control Systems with Random Inputs, Trans IRE, Professional Group on Circuit Theory, No. 1, 1954.
26. Pruden, F. W., Wardlaw, R. L., Baxter, D. C., Orr, J. L. A Study of Wintertime Heat Losses from a Water Surface and of Heat Conservation and Heat Addition to Combat Ice Formation in the St. Lawrence River N R C. Rept No. MD-42, June 1954

EIC

Discussion

Revision of the Reinforced Concrete Section of the National Building Code
Mark W. Huggins, M.E.I.C., Professor, Department of Civil Engineering, University of Toronto
W. B. Plewes, M.E.I.C., Research Officer, Building Structures Section Division of Building Research, National Research Council, Ottawa

The Engineering Journal, February 1962 page 45

Discussion by S. D. Lash, M.E.I.C.

The authors of this paper are to be commended for their clear explanations of the way in which the Concrete Section of the National Building Code 1960 was prepared and for the technical changes in it. Unfortunately it is a disappointing document: disappointing because so few of the results of research carried out during the past 30 years have achieved recognition. The reasons for this lamentable state of affairs are obvious —the Committee was expected to complete its work "in two or three meetings making use of whatever knowledge and experience was immediately at hand and without carrying out any new research or prolonged investigation." The ACI Standard Building Code 318-56 was to be used as the basis with regard to design". The committee was expected to make bricks without straw.

There are good reasons for uniformity of practice with the United States—in such matters as dimensional standards, in symbols and in requirements for the quality of materials. There is much less reason for uniformity of practice in design—perhaps the only good reason is that we commonly use text books by United States authors. It is of course a fact, that very little research in reinforced concrete is being carried out in Canada and consequently we tend to have few convictions of our own and must necessarily copy others. We can, however, if we take the time, base our judgments not on the codes and specifications of other countries but on the results of research in those countries. By so doing we will avoid copying obsolete documents.

Referring now to some of the matters specifically discussed by Professor Huggins and Mr. Plewes.

The shortcomings of the 1953 Code (based on ACI 1951) were clearly indicated by the failure of the U.S. Air Force buildings. Such failures are not likely to occur in buildings designed according to the new Code but a great deal of reinforcing steel will be used to no purpose. Research has clearly shown that shearing unit stress is not the only factor that should be considered in designing beams in regions of high shearing force. If shearing unit stress only is considered, wide variations in safety are bound to occur and if all structures are safe many must be overdesigned.

It is no advance to go back to the Marcus approximations for moments in rectangular plates supported on four sides. Today when digital computers are readily available it makes more sense to solve the Lagrange equations directly. In a paper published in Engineering Journal 20 years ago the writer presented tables of design coefficients very similar to those proposed for the new Code based on a mixture of mathematics and engineering judgment. These were included in the 1941 Code. The values for negative moments were somewhat smaller than those now proposed allowance having been made for re-distribution of moments. It would be interesting to know the evidence for the slab cracking attributed to an underestimation of negative moment. Most cracks in slabs are very small and those caused by negative moments are commonly covered up. By 1961 it appears that the validity of the Johanssen method or yield line method of analysis has been well established. It leads to simpler design procedures and more economical structures. With suitable safeguards it could well have been incorporated in the Code. Yield line analysis was recognized in Danish regulations in 1949.

The soundness of ultimate load design of flexural members has been established beyond all question but this method of design is ignored in the 1960 Code. Recognition was overdue in 1953. In the absence of ultimate design, proper recognition should have been given to high strength reinforcement by permitting reasonable working stresses. There is no sound reason for limiting working stresses in hard grade and rail steel reinforcement to those permitted for intermediate grade reinforcements.

Although it may be premature to give full recognition to ultimate load analysis of continuous beams and frames, some steps could safely have been taken in this direction.

It is suggested that the time is appropriate to start work on a revision of the design section of this chapter of the Code so that proper recognition of the results of research can be made in time for inclusion in the next edition. Not only are the existing regulations in need of review but also the time has come when some regulations should be included governing the design of shells and folded plates.

Authors' Reply to Dr. Lash

Dr. Lash's contribution to this discussion is particularly welcomed because he was a member and secretary of the Reinforced Concrete Committee for the first National Building Code published in 1941. He deplores the fact that we in Canada tend to merely copy the codes and specifications of other countries and the authors tend to agree with him. It is also true that most of the research on reinforced concrete is carried out in other countries and it is possible that we could use the published results of this research to form our own judgments. The fault is, however, that many of the committees in those other countries have, at any given time, the results of a considerable amount of unpublished data which at present is unavailable to us. In view of this, it would seem important that we establish liaison with corresponding

committees in other countries so that we will have access to the same information. We would still be free to form our own judgments, but more important, our committees could make a definite contribution to the work of those other committees on which we at present so much depend. In recent years the ACI in particular has made it clear that it would welcome such liaison.

Prior to about 1950 a great deal of research had been done in many countries on the shear strength of reinforced concrete beams. Most of the testing was done on simple span beams and the maximum nominal shearing stress on a cross section was taken as the measure of the resistance of beams to diagonal tension. Since for most simple beams the concrete will carry some shear up to maximum load the ACI Code required, up to 1951, that all beams be reinforced to carry merely "the excess". Based on some tests that showed that this was not always safe, the German codes went to the other conservative extreme and required that beams be reinforced for the total shear. The difference of opinion existed for years with other countries frequently adopting an intermediate position. The ACI Code of 1951 has been shown to be unsafe for a few cases and the German position is most often over conservative. As Dr. Lash points out the true shear strength of beams is dependent on other factors as well as shear, namely continuity, axial loads, longitudinal steel stress, and location of the loads. A great deal of new information on these factors has been obtained in recent years as a result mainly of the advent of ultimate strength design for which the old rules for evaluating shear were unsatisfactory. An ACI-ASCE Committee has for 10 years been evaluating this new data and it is expected that the results of their efforts will appear in the next ACI Building Code. In the meantime, as a result of some failures, the shear requirements of the NBC were strengthened in clauses issued as revision slips in 1957. These were based on rational thinking about diagonal tension in continuous beams especially in the vicinity of the points of inflection. The Revision Committee for the 1960 NBC found that the main objection to these revisions had been that they were complicated for general use. For this reason it was decided to go a short step further and require all the shear in continuous beams to be taken by stirrups where v_c is greater than 0.03 f'c. Recapitulating what has been said above, in the choice between the old ACI shear clauses which have been shown to be unsafe in a few cases and the other extreme of complete reinforcement for shear, the committee decided in favour of the safe side until such time as new rules are available which take into account all of the variables.

A similar decision was involved with regard to the design of two-way slabs. To begin with it was unfortunate that the Committee did not come across Dr. Lash's excellent paper on the subject published in the EIC Journal of September 1941. That paper describes the elastic analysis of the moments in two-way slabs and the adjustment of the resulting coefficient to take into account plastic flow under long term loads. The paper would have been of considerable assistance to the committee in studying the subject. It is undoubtedly true that plastic flow under long term loads and the formation of cracks at loads near ultimate will cause the peaks of moment found by elastic analysis to be redistributed. Several methods of design require the steel to be distributed in accordance with coefficients that have been calculated elastically but adjusted to take into account such redistribution. Whether or not the steel is distributed according to elastic coefficients or to the adjusted coefficients, the ultimate load of the slab will not be much different. In any case, tests indicate that two-way slabs designed under any presently accepted method have more than ample load factors. At present the British, German and perhaps soon the ACI Code seem to hold the opinion that the steel should be distributed in accordance with elastic coefficients and thus provide resistance to or at least a delay in cracking. In the Marcus method the coefficients closely approach the elastic moments and were adopted by the Committee.

The Johansson Yield Line Theory for slabs is undoubtedly a useful tool for the design of slabs and its use should be permitted in future codes. It is also true that it does not always lead to acceptable slabs from the point of view of deflection and the circumstances surrounding its use would have to be carefully scrutinized by a committee before it is adopted.

Similarly, ultimate strength design and the use of high strength steel should be recognized in the Code. Again such matters as deflection, concrete quality control, load factors, crack control, and steel quality should receive due consideration before such measures are adopted. The Committee recognized these needs and has made recommendations to the Associate Committee regarding the preparation of the necessary clauses for the next revision. EIC

Canadian Developments

Organic Test Reactor to be built at the Whiteshell Nuclear Research Establishment

An engineering test reactor will be built at the Whiteshell Nuclear Establishment near Winnipeg. The Organic Test Reactor is the first major facility to be constructed by Atomic Energy of Canada Limited. Announcement of the construction was made by the Committee of the Privy Council on Scientific and Industrial Research.

The Organic Test Reactor, like others in the Canadian nuclear research and development program, will use heavy water to maintain the chain reaction that burns uranium. To remove heat from the reactor core, the OTR will use organic liquids. The Reactor was designed by the Civilian Atomic Power Division of Canadian General Electric.

The primary purpose of the OTR is to provide facilities for large-scale testing of fuel rods, coolant systems, and components for organic-cooled, heavy-water-moderated power reactors. In addition, the reactor is being designed with flexibility to allow it to be adapted for a variety of engineering tests including those involving other heat media.

The initial output of the reactor, which will begin operation in 1965, will be 25,000 kilowatts with provision for increase to 60,000 kilowatts. The reactor tank, or calandria, will be made of stainless steel and will have 55 aluminum tubes running vertically, end to end. Into these tubes will be inserted the coolant tubes that contain the fuel rods. The coolant tubes may initially consist of stainless steel, and if they do, the uranium oxide fuel will be enriched slightly by increasing the uranium-235 content to 2% from the 0.7% that occurs naturally in uranium. When the preferred materials, such as aluminum alloys, have been fully developed for the fuel channels and for fuel cladding, natural uranium oxide may be used as fuel. Each fuel rod will consist of uranium oxide pellets contained in 19 stainless steel tubes, eight feet long, fastened together in a bundle. The reactor will be shut down for refuelling. A shielded flask will be used to remove used rods, but new rods will be inserted manually. The reactor will be controlled by varying the amount of heavy water in the calandria.

New Reflecting Telescope

Canada's newest and most advanced telescope will soon go into operation at the Victoria Astrophysical Observatory. The 48-inch reflecting telescope with its accessories, is housed in its own domed building on Victoria's Observatory Hill. This new instrument is especially suited for spectroscopic analysis since the light from stars is reflected and magnified by concave and convex mirrors and does not pass through glass.

The telescope, though smaller than the 42-year-old 73-inch telescope, has several important advantages due to its design. The spectroscope, larger than that used with the old telescope, is not attached directly to the telescope, but is housed in a separate room below the dome. The balancing counter-weight has been placed to the rear and below the instrument, enabling it to be pointed at any part of the sky, leaving no blind spots.

The first job of the new telescope will be the investigation of the atmosphere of giant double stars. It will greatly increase the number and variety of observations that can be made. By spectroscopic analysis, the physical properties of stars, their direction and velocity of movement, and interstellar space can be investigated more thoroughly. The new instrument will also be used for direct photography and photoelectric photometry.

Sales Effort By H.E.P.C.

The Hydro Electric Power Commission of Ontario mounted a major sales effort in 1961 in an attempt to diversify loads and increase electrical consumption. This effort was prompted by a less-than-average increase in electrical consumption during the year.

Preliminary figures indicate that 1961 demands increased only 2.7 per cent, compared with 3.4 per cent the previous year. Revenue increased by 3.5 per cent, compared with 7.6 per cent in 1960.

The objective of the program undertaken by the Commission and the municipal electrical utilities is to encourage more diversified use of electricity over 24 hours. This would result in the most economic and efficient use of available capacity. To accomplish this it was felt necessary to encourage a steady growth in the sale and use of all electrical equipment and appliances.

Encouraging results have been shown in the concerted promotional campaign by the Commission and the municipal utilities in co-operation with the manufacturers, distributors and dealers. Co-operative appliance promotions undertaken during 1961 are showing the desired effect. Sales efforts in recent months have increased the consumption of electricity by an estimated 22 million kilowatt-hours.

The bulk of the Commission's 1961 capital expenditures of more than $125 million was for new generating facilities. During the year 606,000 kilowatts of capacity were installed. This new generation came from the Otter Rapids and Red Rock Falls hydro installations in northern Ontario, and from the Lakeview and Richard L. Hearn thermal stations near Toronto.

This year in Ontario will see Canada's first nuclear electric power station in operation with a capacity of 20,000 kilowatts. Other power sources coming into service will be the second 300,000 kilowatt unit at Lakeview, and a 100,000 kilowatt unit at Thunder Bay, the Commission's first major thermal electric power station in Northwestern Ontario.

EIC

Annual Meeting
of the
Engineering Institute
of Canada

Queen Elizabeth Hotel
Montreal
June 11-15, 1962

75th Anniversary
Meeting

International News

Sweden's Nuclear Program

Sweden's Atomic Energy Board has recommended $30 million in State appropriations for nuclear energy purposes for the 1962-63 fiscal year. The recommendation is in line with the guiding principles of Sweden's atomic reactor development program which were set down more than five years ago. The program is aimed at local design and manufacture of reactors specially adapted to that country's requirements.

Plans for the development of commercial power reactors in Sweden are based on the use of natural uranium as fuel and heavy water as moderator. The Board says the aim should be at units producing 300 to 500 Mw. Since existing commercially exploitable hydro resources are likely to have been harnessed in the 1970's, and as thermal power stations burning imported oil would put too heavy a strain on the country's balance of trade, atomic power would have to be introduced on a major scale in the period between 1970 and 1975.

Sweden's first experience in designing and manufacturing complicated power reactors was gained in building the Agesta combined power and heating reactor outside Stockholm. This unit is scheduled to go into operation early in 1963. As it has proved impossible, principally from a manufacturing point of view, to pass directly from this 65 Mw. unit to a full-scale power plant, the 105-Mw. Marviken project has been launched as an intermediate step.

Seven Point Plan for Case

Case Institute of Technology, Cleveland, has announced a seven-point plan designed to guide its increasing responsibilities. The announcement was made shortly after Case received an $8 million grant from the Ford Foundation.

The major needs of Case, as outlined in a booklet issued over the signature of President T. Keith Glennan, are:

1. To increase the number of full-time faculty and professorial members from the present 163 to a minimum of 235 and to increase the salaries of the present faculty;
2. To increase the undergraduate enrollment from 1,600 to between 2,000 and 2,200 consistent with the maintenance of the highest quality;
3. To increase the resident graduate enrollment from 460 to 800 plus 60 post-doctoral fellows;
4. To increase the quality of graduate engineering education;
5. To increase research to a level adequate to sustain the faculty and graduate and undergraduate students of leadership rank;
6. To provide undergraduate housing, creating for students an environment vital to Case's concept of learning;
7. To provide land and facilities necessary for planned growth.

The annual operating budget will increase from $6,860,000 in 1960-61 to $15,260,000 in 1970-71. Major areas of increase will range from anticipated expenditures for instruction from $2.2 million to $4.2 million during this period, while sponsored research will increase from $2.5 million to $6 million. Another major increase will be in the area of student aid in the form of scholarships and fellowships which will increase from a yearly basis of $451,000 to $1,240,000. In addition, projected capital requirements for the decade include a planned $15 million increase to the endowment and $15.7 for plant additions.

Netherlands Developments

Expansion and development plans have been undertaken by three major firms in the Netherlands. Esso Nederland Limited will expand its refinery in the Rotterdam port area with a chemical plant for the production of aromatic hydrocarbons. Construction will begin early this year with operations scheduled to start in late 1963. This plant, having a total investment of approximately $20 million, will be concerned with the production of benzene, toluene and xylene with an annual output of 200,000 tons.

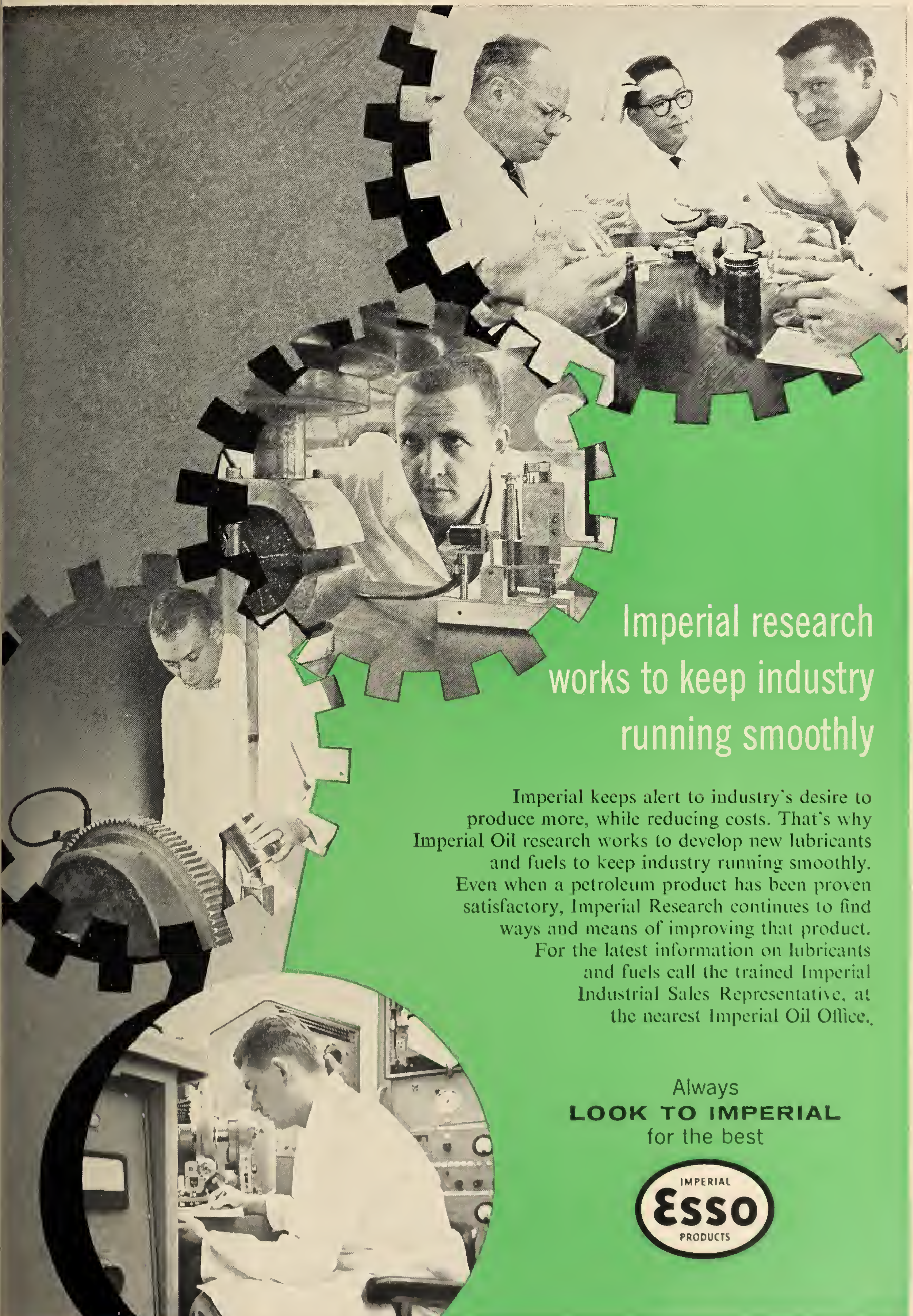
Another development is a paper mill which will manufacture wood-free specialty grades of paper and paperboard. This mill will be built on the site of one of Holland's oldest paper companies, Van Gelder Zonen Limited. It will have a planned capacity of 50,000 tons per year. The management of this new company will be entrusted to Van Gelder.

Situated on the North Sea coast near Amsterdam will be the fifth blast furnace of the Hoogovens Steel Works, which started operations on December 12, 1961. Together with other enlargements of the steel factory to be completed in 1964, steel output of the works will rise to 2,450,000 tons a year, and production capacity to five million tons.

WORLD REGISTER OF DAMS

On page 108 of the January issue of the Engineering Journal an appeal was made for information concerning little-known dams in Canada which might be included in the World Registry of Dams.

It would be appreciated if this information could be forwarded to: J. K. Sexton, Chairman, Canadian National Committee, International Commission on Large Dams, 35 York Street, Westmount, Montreal 6, P.Q.


Imperial research
works to keep industry
running smoothly
Imperial keeps alert to industry's desire to produce more, while reducing costs. That's why Imperial Oil research works to develop new lubricants and fuels to keep industry running smoothly. Even when a petroleum product has been proven satisfactory, Imperial Research continues to find ways and means of improving that product. For the latest information on lubricants and fuels call the trained Imperial Industrial Sales Representative, at the nearest Imperial Oil Office.
Always
LOOK TO IMPERIAL
for the best
IMPERIAL
ESSO
PRODUCTS

PROGRESS REPORT REGARDING CONFEDERATION

Joint statement from the Executive Committee of the C.C.P.E. and the E.I.C. to the membership regarding Confederation.

The Final Report of the Engineers' Confederation Commission was received by the Annual Meetings of the EIC and CCPE in the summer of 1961. At that time, both bodies authorized their Executive Committees to study the report and to discuss it with the Executive Committee of the other body in an effort to come to agreement about the report and to draw up a logical plan of action.

On July 13, 1961, the two Executive Committees met at a joint meeting in Ottawa. At this time it became apparent that the EIC and the constituent associations of the CCPE would have points to discuss and clarify in connection with the report. It was agreed that some of these points from both CCPE and EIC would be referred to the Engineers' Confederation Commission, and, if acceptable to the Commission, appropriate revisions would be made in the report. It was agreed further that the report would then be published in the September 1961 issue of THE ENGINEERING JOURNAL. Furthermore, both CCPE and EIC agreed to devote additional study to the Commission's report, and to obtain information on all points in connection with the comments from the EIC membership and the CCPE constituent bodies.

Subsequently, the CCPE requested each provincial association to examine the report and to advise the CCPE whether or not they approved of the report in principle, and also to outline any points which they would like to have changed.

In the meantime, the Engineers' Confederation Commission agreed to all the preliminary changes which had been suggested, and the revised report was published in the September 1961 issue of THE ENGINEERING JOURNAL. In an introductory note, the President requested all members, Branch Executives and Councillors to study the report in detail and forward their comments.

To implement the instructions of the EIC Council, the Executive Committee appointed two sub-committees, one with the President as Chairman, to review the report in detail and to receive and consider the comments requested, and the second chaired by Mr. G. W. Martin, EIC Vice-President and Chairman of the Finance Committee, to review the financial implications of the report. Both of these sub-committees reported to the Executive Committee on October 19. The Executive Committee reported to the Council on October 28, and presented a list of points in the report of the Engineers' Confederation Commission to be resolved jointly with the CCPE Executive Committee.

The two Executive Committees met together in Montreal on December 15, 1961, at which the points raised by the EIC were presented to the CCPE, and the points raised up to that time by the provincial associations were presented to the EIC by the CCPE, although some of the provincial associations had not completed their study of the report and had only submitted preliminary reports. After discussing these items, it was agreed that the CCPE Executive could discuss them with their constituent member bodies, and the points raised by the CCPE could be studied by the EIC. When these studies have been completed, the two Presidents will arrange a further joint meeting of the two Executive Committees.

The discussions at both joint meetings made it very obvious that, even though a great deal was accomplished by the excellent work of the Engineers' Confederation Commission, there are still a number of items of policy which must be examined and resolved by the CCPE and EIC before referring a final plan for confederation to the membership for vote. Every effort is being made to complete this heavy task with dispatch, and it is hoped that arrangements may be completed for a referendum of the membership in the spring of 1963. This is the earliest date by which views from all participating bodies may be reconciled.

C. C. P. E.

For the information of our readers the Canadian Council of Professional Engineers is the coordinating body of the eleven provincial and territorial associations or corporation of professional engineers in Canada.

It is concerned with all the areas of activity of its constituent bodies, but concentrates its attention on matters which are national in scope or can most effectively be dealt with at the national level.

The Council has no authority over the provincial associations, but may act on their behalf in matters of a Canada-wide nature.

In relation to the Confederation proposal, the Executive Committee of Canadian Council has been given the responsibility of reconciling the views of the associations and work out a plan which would be acceptable to all concerned.

EIC

Beaver Bill says:

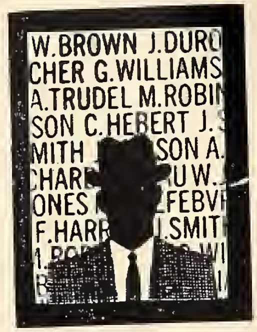
You know, John, I was surprised to hear you remark last night you were disappointed to see the small turnout at your Branch meeting the other night when Al Electric spoke on a subject you considered to be outstanding. I have no doubt it was outstanding because Al Electric is one of those engineer-scientists who is helping to push back the frontiers of knowledge, and make know-how available. He is playing a vital role in developing new elements of our economy. This is sometimes the case, John.

Often an expert does not prove to be a "crowd puller". On the other hand, if the people who participated in the meeting, and particularly in the discussion, grasped something of the speaker's vision, then it was a first-rate meeting. It is the quality of participation which counts, not the numbers.

I'll be looking forward to seeing you the next time you are in town.

Yours sincerely,

Personals



S. George Barber, M.E.I.C. (Toronto '50) has been appointed as Chief Municipal Engineer of Marshall Macklin Monaghan Limited. After four years as a district engineer with the Ontario Department of Health, Mr. Barber joined this firm in 1956. His professional career has been concentrated in the municipal engineering field.

J. T. Cawley, M.E.I.C. (Toronto '43) has been appointed to advise the Indonesian government on the administration of its oil industry, and to assist in the establishment of a university course in petroleum engineering. Mr. Cawley is Saskatchewan's deputy minister of mineral resources, and his appointment was made through the United Nations' Technical Assistance Administration.

Edward W. Hill, M.E.I.C. (Toronto '48) has been appointed as Marketing Manager for the Canadian Westinghouse Switchgear and Control division. His previous position was Manager of the company's Utility Department. He joined Westinghouse in 1948 and was engaged in design engineering for three years, then became manager of Switchgear Sales in 1953.

R. L. Kennedy, M.E.I.C. (Toronto '48) was appointed as Vice-President in charge of Sales, Industrial-Medical Division, for Liquid Carbonic Canadian Corporation Limited. Mr. Kennedy was formerly Manager of Liquid Carbonic's Vancouver office.

Stuart Lyon, M.E.I.C. (Toronto '54) has rejoined Frankipile South Africa (Pty.) Limited as Piling Supervisor, Natal, after an absence of five years spent in South and Central America, Europe and Canada.

A. B. Sanderson, M.E.I.C. (U.B.C. '33) has been elected the new President of the Association of Professional Engineers of British Columbia.

Ralph A. Yates, M.E.I.C. (Toronto '49) has been elected as President of Wakefield Lighting Limited, succeeding T. D. Wakefield who became Chairman of the Board. Mr. Yates has held the position of Vice President since the company was incorporated in 1953. He will continue to serve as general manager.

A. D. Tidsbury, M.E.I.C. (Univ. Alta. '50) has joined the staff of Cabeen Exploration Corporation as a mining engineer. Mr. Tidsbury has had several years of mining experience in Western Canada, United States and Mexico, both for major mining companies and as a consultant. He has most recently been employed by British American Oil Company in their mechanical engineering department. Mr. Tidsbury will be located at the Calgary office of the Company, and will initially be engaged in the evaluation of several properties under investigation by the Company in British Columbia.

H. William Tate, M.E.I.C. (Toronto '10) transportation consultant and a principal of Ewbank, Tupper and Associates Limited of Toronto has been made an honorary life member of the Canadian Transit Association. Mr. Tate, a Life Member of the Engineering Institute, was awarded a special certificate in recognition of his outstanding leadership and contribution to the progressive development of urban transit in Canada.

Duncan M. Stewart, A.M.E.I.C. (Sask. '59) has recently accepted the position of technical sales engineer for DeSpirt Mosaic & Marble Co. Limited, Toronto, where he will be dealing with precast exposed aggregate curtain walls and precast concrete structural members.

Everett R. Magnusson, M.E.I.C. (U.N.B. '48) has been appointed Technical Officer of the Canadian Institute of Timber Construction. He will be situated at the new branch office in Toronto.

C. W. Sparrow, M.E.I.C. (Man. '28) has been appointed Assistant General Manager in charge of Marketing and Long Range Planning at Saskatchewan Government Telephones. Mr. Sparrow began his career as an apprentice switchman. Subsequently, he held positions of Transmission and Equipment Engineer and Chief Engineer. He was appointed Manager Operations and Engineering in 1959.

William G. Miller, M.E.I.C. (N.S.T.C. '53), a former president of Montreal Locomotive Works Limited, has been elected President of Alco Products Inc. He succeeds William S. Morris.

J. C. Browning, M.E.I.C. (U.B.C. '50) has been appointed Manager, Refining Department of the Royalite Oil Company, with headquarters at the Company's Head Office in Calgary. Prior to this appointment, he was Refinery Superintendent at the Saskatoon Refinery. Mr. Browning will be in charge of all the Company's refining operations. This position has been newly established to further co-ordinate the Company's refining operations.

W. R. Ford, M.E.I.C. (McGill '44) has been promoted to Chief Engineer of the Canada Cement Company. He joined the Company in 1949.

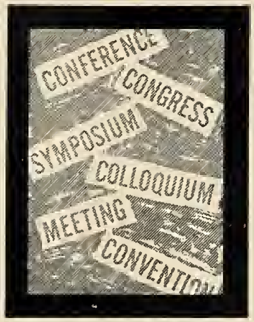
Joseph A. D'Angelo, M.E.I.C. (Man. '46) has been appointed comptroller of the Chrysler Corporation forge plant located in New Castle, Ind.

R. T. Bogle, M.E.I.C. (U.B.C. '40) has been appointed General Manager of the Engineering Division of the John Inglis Company Ltd. as well as the English Electric Division.

W. L. Campkin, M.E.I.C., has been appointed Acting General Plant Manager at Saskatchewan Government Telephones. Mr. Campkin joined the System in 1919 as a switchman. He was appointed head switchman in 1922, Equipment Supervisor in 1931, and General Plant Supervisor in 1946. EIC

If you have recently had an APPOINTMENT or TRANSFER, let *The Engineering Journal's* editorial department know about it for a PERSONALS item. If you have a recent PHOTOGRAPH, send that too.
Address all information to The Engineering Journal, Editorial, 2050 Mansfield Street, Montreal 2, P.Q.

Other Societies



AIME Award Winners

A Canadian steel executive and a 27-year-old American metallurgist have had their achievements recognized by the American Institute of Mining, Metallurgical, and Petroleum Engineers.

Harold M. Griffith of Hamilton, Vice-President, Operations, The Steel Company of Canada, Ltd., is the recipient of the Benjamin F. Fairless Award. This award recognizes distinguished achievement in iron and steel production and ferrous metallurgy. Mr. Griffith began his career with Bethlehem Steel Corporation at Aliquppa, Pa., as open hearth metallurgist. He left in 1935 to become steel works metallurgist with STELCO. Following a series of promotions he became Vice-President in charge of operations in 1953. Mr. Griffith was elected to the Board of Directors in 1959.

Dr. George Stephen Ansell, Assistant Professor, Materials Engineering, at Renssalaer Polytechnic Institute, Troy, N.Y., has been awarded the Robert Lansing Hardy Gold Medal. This Medal recognizes exceptional promise by a metallurgist under 30 years of age. Dr. Ansell was named on the recommendation of The Metallurgical Society of the Institute. His successes at the U.S. Naval Research Laboratory, Washington, D.C., as head of the Metal Physics Consultant Staff and his activities from 1955 until 1958 in that field as a Naval Lieutenant, induced highest praise from his superiors.

Automatic Control Meetings

Two important international Automatic Control conferences will be held during the summer of 1963.

Papers are invited for presentation at the Second Congress of the International Federation of Automatic Control to be held in Basle, Switzerland, in September, 1963, under the auspices of the Swiss Association for Automatic Control. Papers should deal with theory or applications of automatic control. A few papers will be accepted on components of control systems and general items. Further details may be obtained from the Canadian member organization of I.F.A.C. by writing to: The Secretary, Associate Committee on Automatic Control, National Research Council, Ottawa 2.

The University of Texas, Austin, will be the site of the fourth Joint Automatic Control Conference, June 19-21, 1963. Authors of I.F.A.C. papers are urged to submit them also for J.A.C.C. presentation. Abstracts are due at the end of September, 1962, and manuscripts by November 1, 1962. Such dual submission is approved by the American Automatic Control Council, and is in fact encouraged for purposes of practice and criticism. Because of I.F.A.C. copyright restrictions, such papers will be preprinted in abstract only. Of the five member societies of the sponsoring council, the American Institute of Chemical Engineers has prime responsibility for the 1963 J.A.C.C.

Canadian Science Fairs Council

The First Canada-Wide Science will be held May 11-12 at the Science Building of Carleton University, Ottawa. During the school year 1960-61, more than 30 science fairs were held across Canada, and a significant increase is expected during 1961-62. The Canadian Science Fairs Council furnishes information and planning assistance to teachers, community organizations, professional societies and industrial groups in an effort to increase interest in Regional Fairs. Finalists from these Regional Science Fairs will compete for awards

(Continued on page 100)

The Associations and Corporation

A.P.E.B.C.

Eight veteran engineers were awarded Life Memberships at the Annual Meeting of the Association of Professional Engineers of British Columbia. They were presented with gold medallions for their registration certificates. Left to right, front row: H. H. Allen, Victoria; E. S. Jones, Victoria; L. R. Andrews, Vancouver; and Harold Lynum, West Vancouver. Back row: A. G. Phillips, Victoria; William Waters, Victoria; A. S. Gentles, Vancouver. One Life Member, W. K. Willis, of Victoria, was unable to attend because of illness. The President and Registrar visited him the evening before and presented his medallion in a special bedside ceremony.

Reinforced holes in beam sections will carry services.

Eliminate waste spac

Waste space costs money to enclose and maintain. In multi-storied steel frame buildings floor thicknesses including services are at a minimum. Air conditioning and other services go *through* the steel beams. The whole building is lower and lighter and less exterior surface material is required. These are some of the savings you get with steel—savings that must not be overlooked when framing prices are considered.

nditioning ducts go through the steel beams.

Steam and water pipes are carried through the steel.

l permits longer spans for a given beam di-
sion than is practical with other materials.

Haunched steel columns in this multi-storey hotel allow a greater rentable floor area.

. USE STEEL

f you are planning construction, consider carefully the merits of steel. Dominion Bridge s design engineers and fabricating facilities in most of the major cities. The extent their experience and the quality of their performance have few equals in Canada.

88

Structural Division **DOMINION BRIDGE**

FIFTEEN PLANTS COAST-TO-COAST

News of the Branches

Amherst

G. C. L. McEnery, M.E.I.C.
Correspondent

The monthly meeting of the Branch was held December 15, 1961, at the Fort Cumberland Hotel in Amherst. W. A. MacDonald, M.E.I.C., Manager of the Seaboard Power Corporation Ltd., of Sydney, spoke on the aims and objectives of the Association of Professional Engineers of Nova Scotia. The lecture was the second in a series to familiarize the members with the various aspects of Confederation. Mr. MacDonald was introduced by W. D. Hagan, Chairman of the Branch, and thanked by H. M. Smith on behalf of the members.

Belleville

A. F. G. Tooth, M.E.I.C.
Correspondent

Capt. J. Fawcett, Adjutant of the Special Militia Training Program in Belleville, was guest speaker at the Branch's meeting of December 11. His topic was National Survival, with particular emphasis on civilian rescue work in the event of a nuclear attack.

Capt. Fawcett said that a nuclear explosion would not necessarily mean the destruction of all life in that area. Although there were 85,000 casualties at Hiroshima there were people who survived within 500 yards of the actual explosion. This would be inside ground zero. Normally it is expected that rescue may be effected within a zone around the explosion area designated as between the Green Line and the Red Line. This band could be one to eight miles wide around ground zero, depending on wind direction.

Rescue operations would be set up in different phases beginning with reconnaissance of the affected area to check on radio-activity and to determine the safe area for rescue personnel to enter for a limited time. The Mobile Support Column would meet with civilian wardens in the area to direct the operations of the rescue groups. This would involve the location and removal of trapped casualties in various parts of heavily damaged buildings, followed by an extensive and thorough search of the area for other casualties not found during the first search. Before finally leaving the area a further exploration would be made to ensure, as far as possible, that all survivors had been located and given the appropriate attention.

Capt. Fawcett concluded by noting that experience has shown that civilians generally co-operate effectively under military guidance. In the event of disaster it would be necessary for all able-bodied citizens to give their assistance to the Militia, particularly in any capacity in which they have special training.

Capt. Fawcett was introduced by E. Flynn and thanked by S. Sillitoe.

Border Cities

V. Corin, A.M.E.I.C.
Correspondent

Sixty members and guests attended the November 15 dinner meeting at the Elmwood Casino. The guest speaker was M. J. Reetham Clayton of International Underwater Contractors Ltd., who showed and discussed the films "Diving School" and "Wreck Busters". "Diving School" was an outline of training required prior to qualification as a diver. It demonstrated the application of special equipment and skills varying from underwater welding to photography. "Wreck Busters" showed the application of this specialized field in the removal of a sunken ship from the bottom of Montreal harbor.

The attending group showed great interest in the subject and a lively discussion followed the films.

The annual general business meeting of the Branch was held December 13, 1961, at the Prince Edward Hotel. Reports of the year's activities were presented, and the following were elected to the Branch executive for 1962: F. P. Mascarin, Chairman; R. L. Kennedy, Vice-Chairman; W. A. MacDonald, Secretary; V. Corin, Treasurer; R. D. Gilbert, W. L. Lucian, H. Grunwell, Executive Committee; W. P. Augustine, Branch Representative of Assumption University Senate; C. M. Armstrong, Nominating Committee; and R. H. Darke, Past Chairman of the Branch. After completion of the business, four students showed films and discussed their summer employment in Wales, England and Germany during a recent student exchange.

Kitchener

A. R. LeFeuvre, M.E.I.C.
Correspondent

An engineering study of radioactive contamination of surface runoff was discussed by an assistant professor of civil engineering at University of Waterloo at a recent meeting of the Branch. Dealt with were methods and results of a five year survey of radioactive contamination in the surface waters in Texas. Following the technical session there was a discussion regarding Confederation.

Cape Breton

Lloyd Boutilier, M.E.I.C.
Correspondent

A combustion engineer with Dominion Steel and Coal Company told the Branch at its November 29 meeting that there is a great potential coal market through heating by electricity. Paul R. Terry, M.E.I.C., who also is a member of the Branch executive, sparked one of the year's most successful meetings.

"Space heating by electricity is the ultimate in modern heating and is winning popular acceptance in both the United States and Ontario." Mr. Terry said.

"Coal, through the medium of electricity, can give the public a brand of space heating that has no equal and is just as practical in Nova Scotia as it is elsewhere."

"Even if only one-quarter of the new homes which are expected to be constructed in Nova Scotia during the next 10 years were heated by electricity, this together with commercial buildings would mean a market for one million tons of coal."

Mr. Terry said that a test house case at Sydney showed space heating by electricity to be more expensive, but the difference in cost was expected to be reduced.

"The ultimate in modern living," Mr. Terry said, "is the 'all-electric home'."

"To convince new customers that the obvious advantages, together with hidden values, make it worth paying more for electric heat will require sales promotion of a very high order, and a concentrated team effort will be needed by all concerned — power companies, public utilities, equipment manufacturers, architects, contractors and the prime-fuel suppliers."

"No one has a bigger stake in this game than coal, because it is the best way the industry can win back a share of the valuable space heating."

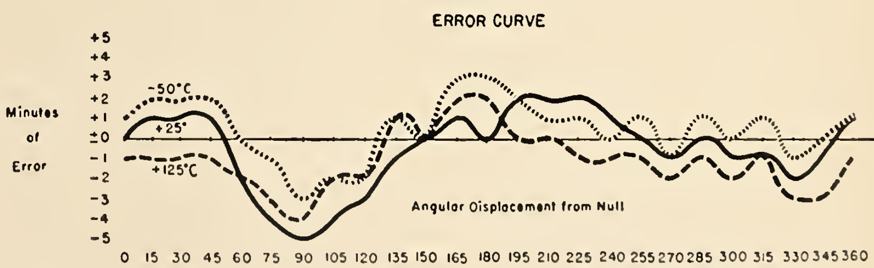
(Continued on page 100)

This Canadian-made SYNCHRO offers temperature stability plus lightness

This Size 8 Daystrom synchro provides temperature stability without increasing weight.

The encapsulated stator windings permit these units to be operated under severe environmental conditions. And, of greatest importance, in random sampling of Daystrom Size 8 synchros, error shift from room temperature has not exceeded 2 minutes over the entire temperature range of −55C to +125C.

Daystrom Size 8 "temperature stable" units are available as transmitters, differentials, control transformers and resolvers. Standard accuracy is ±7 minutes, but 5-minute units are also available on special order.



Data sheets and prints on the "temperature stable" Size 8 synchro are available on request. And remember, too, Daystrom makes a complete line of precision rotating components.

For more information, call or write Daystrom Limited, 1480 Dundas Highway E., Cooksville, Ontario; 5430 Ferrier Street, Montreal 9, Quebec. A subsidiary of Daystrom, Incorporated.

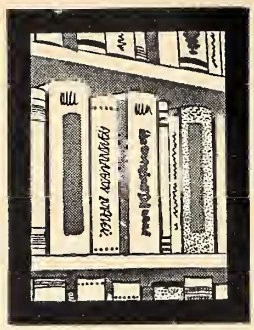
CANADIAN PLANT—COOKSVILLE, ONT.

6134

DAYSTROM LIMITED

WORLD LEADERS IN MEASUREMENT AND CONTROL

Library Notes



Prepared by the Library, The Engineering Institute of Canada

Book notes marked by an asterisk have been provided through the courtesy of The Engineering Societies Library in New York.

***1961 HEAT TRANSFER AND FLUID MECHANICS INSTITUTE, PROCEEDINGS.**

Seventeen papers are included in this volume which deals with such topics as the stagnation point on blunt bodies of revolution, the interaction of the reflected shock wave with the laminar boundary layer on the shock tube walls, the finite difference solution of laminar boundary layer problems, two-phase steam-water flows, the use of acoustic vibrations to improve heat transfer, spray-type condensers, hypersonic strong viscous interaction on a flat plate with surface mass transfer, hypersonic shock-layer theory of the stagnation region at low Reynolds number, ionization trails, transpiration cooled anode of an electric arc, and heat transfer through a melting layer with external gas flow. This is a pre-print volume of the papers presented at the Institute, held at the University of Southern California, June 1961. (Ed. by R. C. Binder & others. Stanford, University Press, 1961. 236p., $8.00.)

***LINEAR GRAPHS AND ELECTRICAL NETWORKS.**

The authors have developed their material from lectures they have given in graduate courses in various U.S. universities. Prior knowledge of matrix and Boolean algebra, Laplace transformation, and theory of functions is assumed, but the special concepts of linear algebra, upon which the theory of graphs depends, are explained. To establish the foundations of network theory, the authors determine the mathematical properties of the Kirchhoff equations by means of the linear graph, as it determines the coefficient matrices of these equations. The first five chapters contain the basic theory of graphs, and the last five (two-thirds of the book) discuss various applications, such as in network analysis and synthesis, the theory of switching, topological formulas, communications networks, and flow graphs. (Sundaram Seshu and M. B. Reed. Reading, Addison-Wesley, 1961. 315p., $9.75.)

***CYBERNETICS, 2nd ed.**

This classical work deals with the application of statistical mechanics methods to communications engineering, with subject matter ranging from such control mechanisms as mathematical calculators to the nerves and brain of the human body. This edition has been completely re-edited, and contains two new chapters by Dr. Wiener on learning and self-reproducing machines and on brain waves and self-organizing systems. (Norbert Wiener. New York, Wiley, 1961. 212p., $6.50.)

***RELATIONS DE DISPERSION ET PARTICLES ELEMENTAIRES.**

A collection of papers, some in English and some in French, dealing with such topics as the theory and applications of dispersion relations, analytic functions of several complex variables, properties of vacuum expectation values of field operators, double dispersion relations and unitarity as the basis for a dynamical theory of strong interactions, weak interactions, and strong interactions of strange particles. C. DeWitt and R. Omnes. New York, Wiley, 1960. 671p., $20.00.)

***INDUSTRIAL FURNACES, VOLUME I, 5th ed.**

The basic principles underlying all furnace design and operation are presented with numerous graphic illustrations and typical examples. In this edition material on obsolete furnace designs has been replaced by discussions of more modern types of furnaces. In addition a separate chapter is given on the theory and calculation of heat transfer within a furnace enclosure. An expanded treatment of the capacity of modern forced-convection furnace and of modern axial heating furnaces is also given. (W. Trinks and M. H. Mawhinney. New York, Wiley, 1961. 486p., $17.00.)

THE ENGINEERING INSTITUTE LIBRARY

The publications mentioned in these notes are now available in the Library, and may be borrowed by members of the Institute. Two items may be borrowed at one time for a period of two weeks, excluding time in transit.

Library hours are: Monday to Friday: 9 a.m. to 5 p.m.; Saturdays: 9 a.m. to 12 noon. All requests and enquiries should be addressed to the Librarian at 2050 Mansfield Street, Montreal.

EFFECTIVE COLLEGE RECRUITING.

The results of a study undertaken in 1960 by the Bureau of Industrial Relations of the University of Michigan, intended to show what effective college recruiting is. It is based on 193 responses from recruiters and companies, and 1134 from students. It considers such topics as the recruiting process, the college placement office, campus interviewing, student attitudes to recruiters, company recruiting literature. A final chapter tries to explain today's students to the recruiter. (G. S. Odiorne and A. S. Hahn. Ann Arbor, Univ. of Michigan, Bureau of Industrial Relations, 1961. 288p., $5.00.)

***ASPHALT: ITS COMPOSITION, PROPERTIES AND USES.**

The chemical, physical, colloidal, rheological and durability properties of asphalt are presented. This is followed by reviews of asphalt manufacturing methods and the various forms in which it is used, e.g., cutbacks and emulsions. An entire chapter is devoted to mineral fillers and filled asphalts, and the author concludes with descriptions of the major uses of asphalt: road building, roofing, hydraulic structures, and specialties. The overall approach is selective rather than comprehensive. (R. N. Traxler. New York, Reinhold, 1961. 294p., $10.00.)

***THERMOELECTRICITY: SCIENCE AND ENGINEERING.**

This book covers the physics and chemistry of thermoelectric materials, the design of materials, and the device technology. Specific aspects considered include classical and irreversible thermodynamic treatment of thermoelectricity, thermal conduction in thermoelectric materials, measurements of properties of thermoelectric materials, theory of thermoelectric materials, low temperature Peltier cooling, thermionic conversion, theoretical calculation of device performance, and heat transfer problem in thermoelectric devices. (R. R. Heikes and R. W. Ure. New York, Interscience, 1961. 576p., $18.50.)

(Continued on page 94)

THE ENGINEERING INSTITUTE OF CANADA

FOURTH SOUTHERN ONTARIO

REGIONAL CONFERENCE

APRIL 28, 1962.

Hotel London, London, Ontario

PROGRAM

.00 a.m.: Branch Executive Meeting

.30 a.m.: Registration

.30 a.m.: Ladies Program Starts

.15 p.m.: Conference Opened by *Dr. B. G. Ballard* President, E.I.C. "DISCUSSION ON ENGINEERING EDUCATION"

2.00 p.m.: *Dr. L. G. Soderman*—Practical Applications of Recent Advances in Soil Mechanics
M. J. Stoesser—The Plastic Industry—75 Years of Growth

.30 p.m.: *D. L. S. Bate*—Nuclear Power Generation
J. G. Guthrie — The Industrial Group Relationship — Engineer to Management

.00 p.m.: Cocktails & Refreshments

7.00 p.m.: Dinner

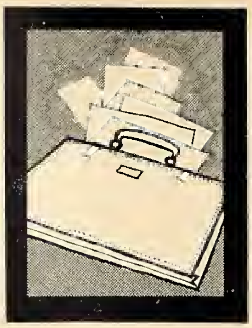
.15 p.m.: *Dr. A. D. Misener* — 75 Years of Engineering Progress

.00 p.m.: Dance

EES: $10 per member; $18 per couple.
(Cocktails, Dinner and Dance only $10 per Couple)

PONSORING BRANCHES: London, Sarnia and Border Cities.

Business and Industrial Briefs



Appointments and Transfers

The board of directors of Canadian Industries Limited has announced that effective March 1, 1962, **Leonard Hynes**, vice-president, will become president of the company and chairman of the executive committee, succeeding **P. C. Allen**, who has been president since January 1959. Mr. Allen is returning to England to assume duties in his capacity as an executive director of Imperial Chemical Industries Limited. He will remain a director of C-I-L, serving as chairman of the board. **W. T. D. Ross**, vice-president, will succeed Mr. Hynes as vice-chairman of the executive committee.

E. A. Burgess, Eastern Area Manager of James Howden & Company of Canada Limited, has been elected a director of the company. Mr. Burgess will direct Howden's Sales and Services program in eastern Canada from the firm's Montreal office.

H. M. King has been appointed to the Ontario sales staff of the James Howden Company of Canada Limited. Mr. King joins Howden after five years with the Trane Company of Canada. He will be in charge of sales and service for Howden in southwest Ontario.

J. M. Rochon, Chief of the Metals and Minerals Division of the Department of Trade and Commerce has been appointed as Commercial Counsellor (Metals and Minerals) in London, England. His territory includes the European Economic Community.

Mr. **A. Bandi**, President, Aviation Electric Limited, has announced the following appointments: **D. R. Taylor**, from Vice-President to Senior Vice-President; **A. Lavendel** from Director, Overhaul Division to Vice-President, Overhaul Division; **C. D. Garbutt**, from Sales and Services Manager to Director Sales & Service; **R. S. Bennett**, from Production Manager to Director of Manufacturing; **E. Wall**, from Manager, Planning and Development to Director of Engineering; **A. H. Davies**, from Assistant Quality Control Manager to Quality Control Manager.

Cassius C. **Belden** has been appointed manager of employee and public relations, and **Ronald H. Tippet** has been appointed manager of public relations of Dominion Bridge Company. Mr. Belden, formerly employee relations manager, joined the company in 1959 after many years of experience in industrial relations and personnel administration in Canada and the United States. Mr. Tippet, Supervisor of Information since 1959, joined the company in 1954 as publications editor.

Thomas A. Yellowlees has been appointed Manager of Public Relations for Canadian General Electric Company Limited. Mr. Yellowlees, who joined the company in 1940, has had wide experience in sales, advertising and public relations in several of the company's major departments. Prior to his present appointment he was Manager of Advertising and Sales Promotion for the Apparatus Department.

Shell Oil has announced several staff changes. **A. C. Hogge**, currently manager of Shellburn refinery near Vancouver, will become manager of the Montreal East refinery. He succeeds **G. A. Lorenz** who will be with Shell in Venezuela. **P. Gordon**, now assistant manager of the Montreal East refinery, will become Manager, manufacturing Head Office, a newly created position. **A. J. Foote** will succeed Mr. Hogge as Manager of the Shellburn Refinery.

A. G. Gillespie has been named Vice-president in charge of marketing for Flygt Canada Limited. Prior to joining this company, Mr. Gillespie had extensive experience in the mining and construction fields for more than 20 years.

William J. Sim has been appointed plant superintendent of Sparling Tank & Manufacturing Company, a subsidiary of Products Tank Line of Canada Ltd. Mr. Sim has had 18 years' experience in the plate fabrication industry. He is a specialist in vessel and plant fabrication for the petro-chemical industries.

John P. **Berryman** has been appointed Equipment Sales Manager for the Industrial-Medical Division of Liquid Carbonic Canadian Corporation Limited. Mr. Berryman, responsible for new product evaluation, sales development and service to the Canadian welding industry, will be located at the Company's Head Office in Montreal.

Robert L. Hatch has been appointed Manager of Product Development Water Control Equipment Division, the Rodney Hunt Machine Company. In this newly created position, Mr. Hatch will have charge of developing programs for the broadening of Rodney Hunt's line of water control equipment.

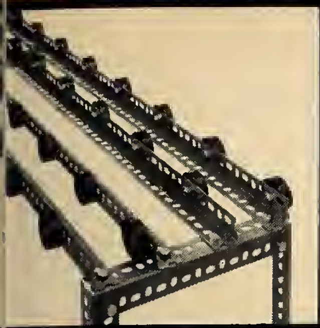
Douglas C. Hodge has been given the additional responsibility of sales contacts with Coach operators in eastern Canada for the General Motors Diesel Limited. Mr. Hodge has been Coach Service Representative, and now he becomes Sales and Service Representative.

Jacob J. Jaeger has been appointed Vice-President Engineering of Massey-Ferguson Ltd. Mr. Jaeger was on the staff of the Massachusetts Institute of Technology for six years, after which he became chief engineer, Vice-President of Engineering, and President of Pratt & Whitney Machine Tool Company in Connecticut.

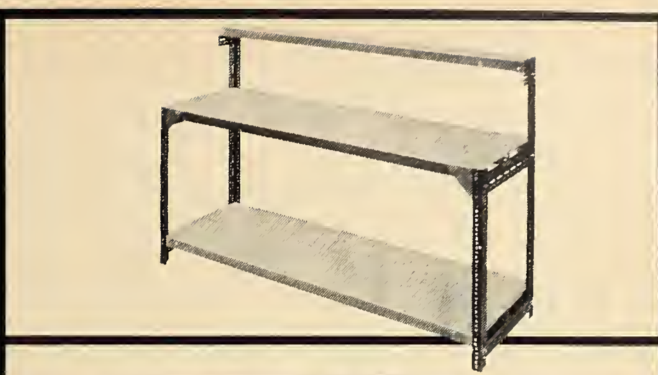
George W. Langston has been appointed General Traffic Manager of Crane Limited, Montreal. Mr. Langston has had many years experience in all phases of transportation work, having joined Crane as Traffic Manager in 1947.

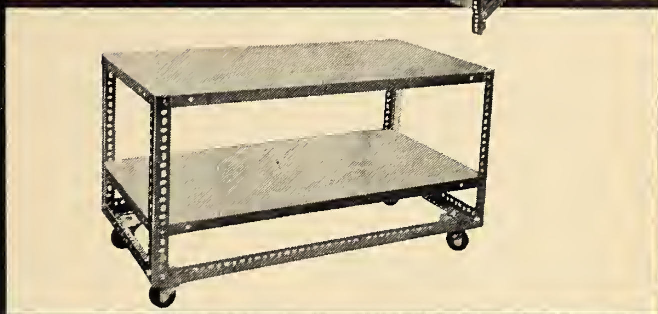
E. J. Trimbee has been appointed Manager of Purchasing for Philco Corporation of Canada Limited. Mr. Trimbee, with the company 20 years, has held several important positions in the purchasing area, and will be responsible for the operation and activities of the Company's purchasing department.

(Continued on page 101)



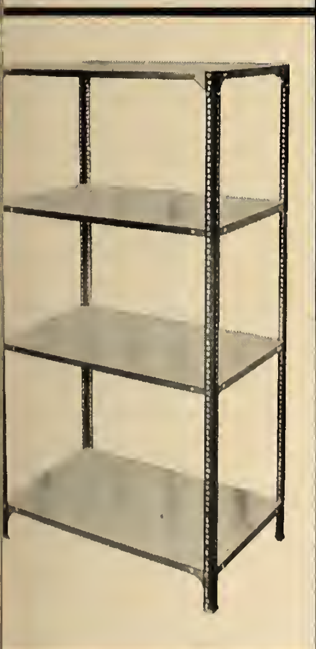
YOU CAN BUILD $1,000 WORTH OF EQUIPMENT FOR ONLY $564. *with*





DEXION

It's so easy to build your own equipment with DEXION — and save dollars! No detailed drawings needed, no skilled labor, no painting. Most of the work — including the measuring — is pre-engineered into every length of DEXION slotted angle. All you do is cut it, bolt it... Tables, trollies, racks, shelves, conveyors — cost you less, do the job better when tailor-made on the spot with DEXION angles and accessories.



With a supply of DEXION angles and accessories on hand, your own staff can easily build many of the items they use every day in factory or warehouse... No baffling search for the right supplier, no costly wait for delivery. No high prices either. DEXION does the job cheaper, faster, better. For all the details, just mail the coupon.

mail this coupon today

DEXION (CANADA) LTD.
114 CLAYSON RD. WESTON, ONT.

☐ Please send free **DEXION** handbook.

NAME____________________

COMPANY____________________

ADDRESS____________________

The Engineering Institute of Canada

Montreal Branch

Conference on Urban Transportation

Montreal March 22 and 23 Windsor Hotel

PROGRAM

Thursday, March 22

8.30 a.m. — Registration

9.15 a.m. — Welcoming Address
C. G. Kingsmill, Chairman
Montreal Branch

9.30 a.m. — *"Transportation in the Modern Metropolis"*
H. Blumenfeld, Town Planner

11.00 a.m. — *"Problèms de Construction du Transport Urbains"*
L. L'Allier, Dir. des Travaux Publics, Montréal

12.30 p.m. — Lunch
Guest Speaker:
Byron T. Kerr,
Mayor of St. Lambert

2.30 p.m. — *"Use of Railway Facilities in Mass Transportation"*
W. Sergeant, Asst. Gen. Supt. Transportation (Tech.)
St. Lawrence Region

3.45 p.m. — *"Paris, Ses Transports Urbains, Son Métropolitain"*
Jacques Gaston, Ing. en chef, Regie Autonome du Transport Parisien

Friday, March 23

9.15 a.m. — Speaker: Jules Archambault, Ing. en chef, Commission de Transport, Montréal

10.45 a.m. — *"Subway Development in Toronto"*
W. H. Paterson, Gen. Mgr. Subway Construction,
Toronto Transit Commission

12.30 p.m. — Lunch
Guest Speaker: Mayor Jean Drapeau

2.30 p.m. — Panel Discussion
"The Economic and Technical Aspects of Urban Transportation in Montreal"
Moderator: Dr. O. N. Solandt, Vice President Research and Development, C.N.R.
Participants: Jules Archambault Ing. en chef, Commission de Transport, Montréal
— Georges Derou, Ing. en chef, Régie Autonome du Transport Parisien
— P. E. Morrissette, Dir. adjoint des Travaux Publics, Montréal
— Claude Robillard, Dir. du Service d'Urbanisme, Montréal
— Messrs. Blumenfeld, Paterson, Archambault

(Continued from page 80)

*STANDARD COSTS FOR MANUFACTURING, 3rd. ed.

Completely revised, this third edition has four sections. Part one discusses the standard cost system, its concepts, development, accounting procedures and variance accounting. Part two is concerned with the setting of cost standards, for direct and indirect labor, materials, utilities, general overhead, and maintenance and other services. In part three the standards are applied to operations, and variances in the costs are discussed, introducing variance analysis, control and tabulation. The final section discusses such miscellaneous items as operating budgets, incentive plans, salary evaluation, and some short cuts in preparation of standards and in accounting. (S. B. Henrici. Toronto, McGraw-Hill, 1960. 402p., $8.50.)

*WATER TREATMENT FOR INDUSTRIAL AND OTHER USES, 2nd. ed.

An extensive discussion of the conditioning and treatment of water supplies for industrial and domestic uses. The material in this edition has been considerably enlarged and rewritten with a view to including many advances within the field and to clarify the presentation where necessary. In particular two new chapters have been added which deal with commercial and institutional water conditioning and with municipal water conditioning. The material dealing with silica removal has been rearranged in a more logical fashion. (Eskel Nordell. New York, Reinhold, 1961. 598p., $12.00.)

*LE CHANTIER DE BATIMENT ET DE TRAVAUX PUBLICS.

A comprehensive and detailed treatment of construction equipment and plant for building and public works. The first section deals with general considerations: organization, buildings and general supplies, financing. Part II covers standard equipment such as scaffolding, earth movers, crushing and screening machines, hoisting and conveying machines, and electric, hydraulic, and compressed air tools. Part III is devoted to specialized equipment for foundation work, highways, bridges and viaducts, shaft sinking, quarries, dredging, etc. Numerous tables provide detailed data on sizes, capacities, etc. for all items considered. (Vittorio Zignoli. Paris, Eyrolles, 1961. 660p., NF 100.15.)

*PLASTICS IN NUCLEAR ENGINEERING.

Practical plastics applications are discussed from the view-point of the engineer dealing with nuclear research apparatus. The author describes the uses of plastics in the measurement of radiation, radiation protection, high-voltage service, low-voltage service, magnets, and high-vacuum apparatus. In addition optical applications and mechanical, thermal, and miscellaneous uses are considered. (J. O. Turner. New York, Reinhold, 1961. 139p., $5.50.)

*PROGRESS IN VERY HIGH PRESSURE RESEARCH.

This volume consists of the papers and discussions presented at an International Conference held at Bolton Landing, Lake George, New York; June 13-14, 1960. In the papers included emphasis is placed upon equipment and techniques, structures of materials formed under high pressure, and behavior of matter under high pressure. In addition the problem of absolute pressure calibration is considered at length, and many optical, electrical, and magnetic changes in materials resulting from decrease of inter-atomic or inter-molecular distances are described. (F. P. Bundy and others. New York, Wiley, 1961. 314p., $12.00.)

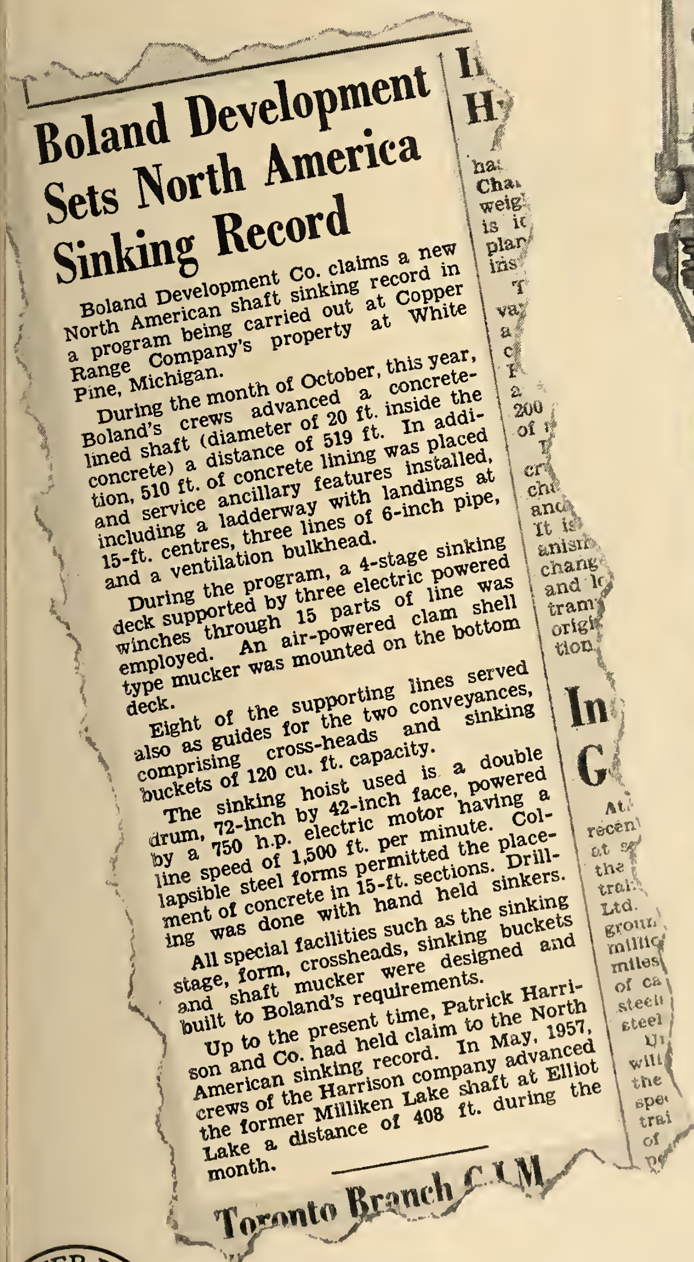
FUNDAMENTALS OF UHF.

Concerned with the basic features of ultra high frequency, from 300 to 3000 mc, the text explains of uhf techniques and equipment, and the differences between communications in this frequency band and at lower frequencies are explained. The topics covered include propagation, transmission lines, resonant lines, oscillators, transmitters, amplifiers and receivers, antennas, and microwave. Also covered are communications and test equipment. (Allan Lytel. New York, Rider, 1961. 153p., $3.90.)

(Continued on page 103)

GARDNER-DENVER'S MODEL S58 SINKER DRILLS SET NEW NORTH AMERICAN SHAFT SINKING RECORD...

Reprinted from the November 23rd issue of THE NORTHERN MINER



Boland Development Sets North America Sinking Record

Boland Development Co. claims a new North American shaft sinking record in a program being carried out at Copper Range Company's property at White Pine, Michigan.

During the month of October, this year, Boland's crews advanced a concrete-lined shaft (diameter of 20 ft. inside the concrete) a distance of 519 ft. In addition, 510 ft. of concrete lining was placed and service ancillary features installed, including a ladderway with landings at 15-ft. centres, three lines of 6-inch pipe, and a ventilation bulkhead.

During the program, a 4-stage sinking deck supported by three electric powered winches through 15 parts of line was employed. An air-powered clam shell type mucker was mounted on the bottom deck.

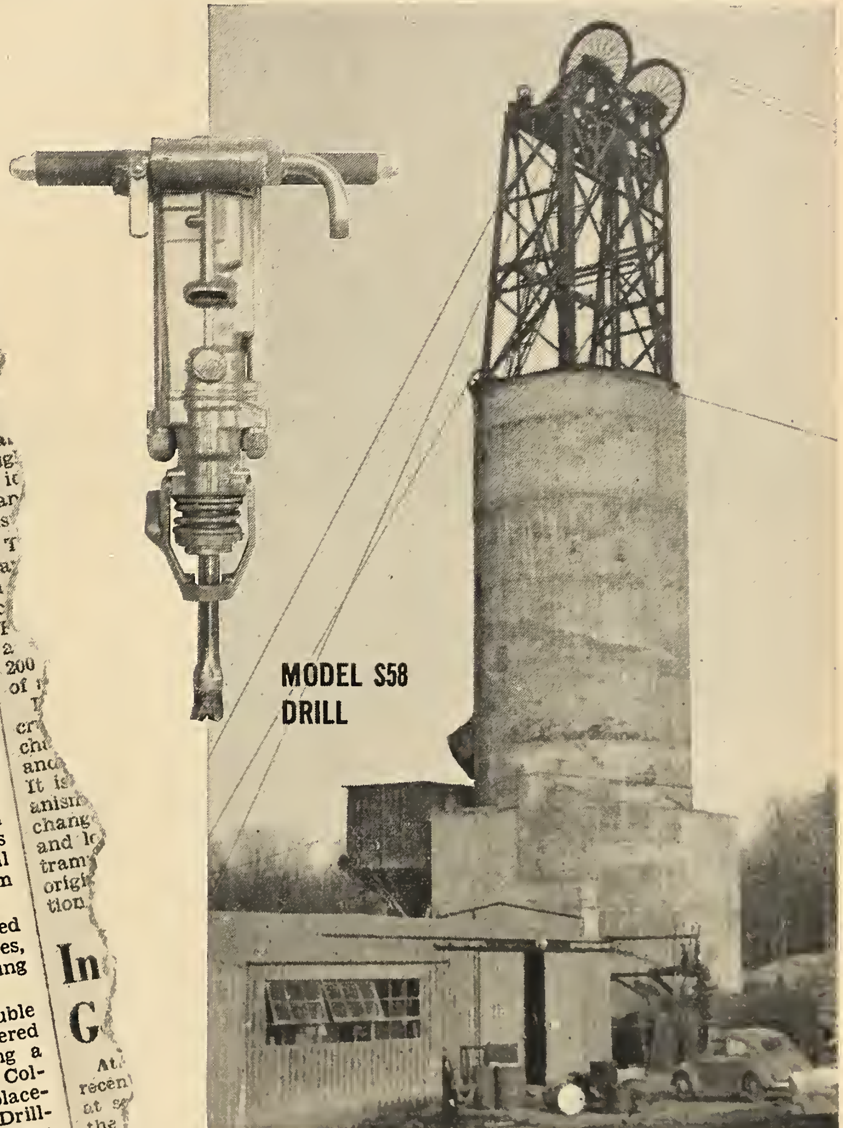
Eight of the supporting lines served also as guides for the two conveyances, comprising cross-heads and sinking buckets of 120 cu. ft. capacity.

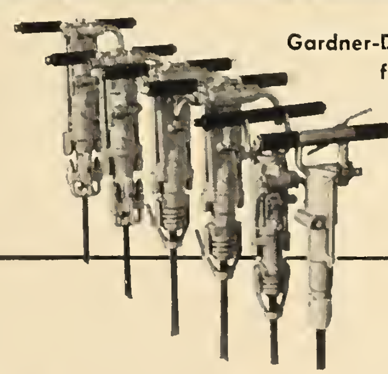
The sinking hoist used is a double drum, 72-inch by 42-inch face, powered by a 750 h.p. electric motor having a line speed of 1,500 ft. per minute. Collapsible steel forms permitted the placement of concrete in 15-ft. sections. Drilling was done with hand held sinkers.

All special facilities such as the sinking stage, form, crossheads, sinking buckets and shaft mucker were designed and built to Boland's requirements.

Up to the present time, Patrick Harrison and Co. had held claim to the North American sinking record. In May, 1957, crews of the Harrison company advanced the former Milliken Lake shaft at Elliot Lake a distance of 408 ft. during the month.

Toronto Branch C.I.M.





Gardner-Denver Sinkers for all types of construction, mining and quarrying.

• OTHER SOCIETIES

(Continued from page 75)

of national significance at the Canada-Wide Fair in Ottawa. The Sponsors of the Council include: Agricultural Institute of Canada; Canadian Association of Physicists; Canadian Conference on Education; Canadian Dental Association; Canadian Education Association; Canadian Federation of Biological Societies; Canadian Medical Association; Canadian Teachers' Federation; Canadian Universities Foundation; Chemical Institute of Canada; Engineering Institute of Canada; Geological Association of Canada; Royal Astronomical Society of Canada.

Coming Events

American Society of Mechanical Engineers Gas Turbine Power Conference. Cleveland, March 4-7.

American Society for Quality Control. Ninth All-Day Forum. Toronto. March 10.

American Society of Tool and Manufacturing Engineers. Annual Meeting. Cleveland. March 15-23.

National Association of Corrosion Engineers. 18th Annual Conference. Kansas City, March 18-22.

Engineering Institute of Canada, Montreal Branch. Urban Transportation Conference. Montreal, March 22-23.

Institute of Radio Engineers. National Convention. New York. March 26-29.

Instrument Society of America. Spring Instrument-Automation Conference and Exhibit. Dallas. March 26-29.

ASME-AIEE-EIC Railway Conference. Toronto. April 9-10.

Engineering Institute of Canada, 4th Southern Ontario Regional Conference. London. April 28.

Eighth Congress Inter-American Association of Sanitary Engineers. Washington, D.C. June 10-15.

Engineering Institute of Canada. Annual Meeting, Montreal, June 12-15.

(Continued from page 75)

C.P.E.Q.

A recent survey conducted by the Quebec Corporation of Professional Engineers revealed that 25% of all Engineers in Quebec are employed by ten firms. Corporation records show that Northern Electric maintains the top position amongst the larger employers of engineers in this province, with a total of 462 engineers. The Bell Telephone Company has 425 engineers. Following are the 10 leading employers of engineers in Quebec: Northern Electric, 462; Bell Telephone, 425; Provincial Government, 397; City of Montreal, 274; Aluminum Company Can., 271; Hydro-Quebec, 195; Canadair 136; Armed Services, 133; Dominion Bridge, 116; Canadian National Railways, 110.

A.P.E.O.

John William Holmes, 38, of Niagara Falls, has been elected President of the Association of Professional Engineers of Ontario. He succeeds L. C. Sentence of Hamilton. Mr. Holmes took office officially at the Association's annual meeting in Toronto January 27. Mr. Holmes is chief engineer and a director of the H. G. Acres and Company Ltd., a consulting engineering firm in Niagara Falls. Elected first Vice-President for 1962, is Robert L. Hicks of Toronto, an engineer with the Toronto Hydro-electric System. Donald L. Angus, of Toronto, was elected second Vice-President.

(Continued from page 78)

An excellent discussion followed Mr. Terry's talk. The speaker was introduced by R. A. Bradley and thanked by H. C. Maitland.

During the December 13 business meeting, the following officers were elected for 1962: Chairman, Mr. Maitland; Vice-Chairman, J. S. Stevens; Treasurer, J. C. Campbell; Secretary, L. R. Boutilier; Executive members R. C. Bezanson, J. J. Laffin, W. R. Lewis, B. St. C. Langille, J. W. Farrel and W. E. MacDonald.

(Continued from page 88)

Carl C. **Agar**, the founder of Okanagan Helicopter Ltd., is retiring after many years of distinctive service to this field of aviation. Mr. Agar will continue as a Director of the Company and consultant on technical matters.

Pumps and Softeners Limited, London, Ont. has announced the appointment of **Stewart A. McWilliam** to the department of Industrial Development and Design. His new position will include the design of additional equipment to round out the Company's water treatment facilities with particular responsibility for pollution treatment.

J. R. Tansony, has been appointed Chief Engineer of Indufab Limited, Toronto. Mr. Tansony has been a design and application engineer for the past two years.

R. B. Carpenter has been appointed works manager of the Calgary explosives plant of Canadian Industries Limited. Mr. Carpenter succeeds **R. J. Nixon**, who has been appointed sales administrator at the Head Office in Montreal.

Allan A. Rowan-Legg has been elected Vice-President and General Manager of Garlock of Canada Limited. He suceeds **Edwin W. Reese**. Rowan-Legg will be responsible for marketing and manufacturing.

F. A. Tremblay has been appointed local Sales Manager, Sept-Iles, Que. for the explosives division of Canadian Industries Limited. Mr. Tremblay joined C-I-L in 1952 at Montreal.

W. C. Turner, Chairman of the Board, has announced the election of **T. W. Wilson** as president of Canadian Bitumuls Company Limited.

International Business Machines has named two new senior officers. **G. H. Sheppard** has been elected Chairman of the Board and **J. E. Brent** has been named President and Chief Executive Officer. Mr. Sheppard has served in various managerial positions since joining IBM in 1929. He was named President in 1945. Mr. Brent, joined IBM in 1931, was Vice-President in 1949, and Executive Vice-President of IBM World Trade Corporation in New York.

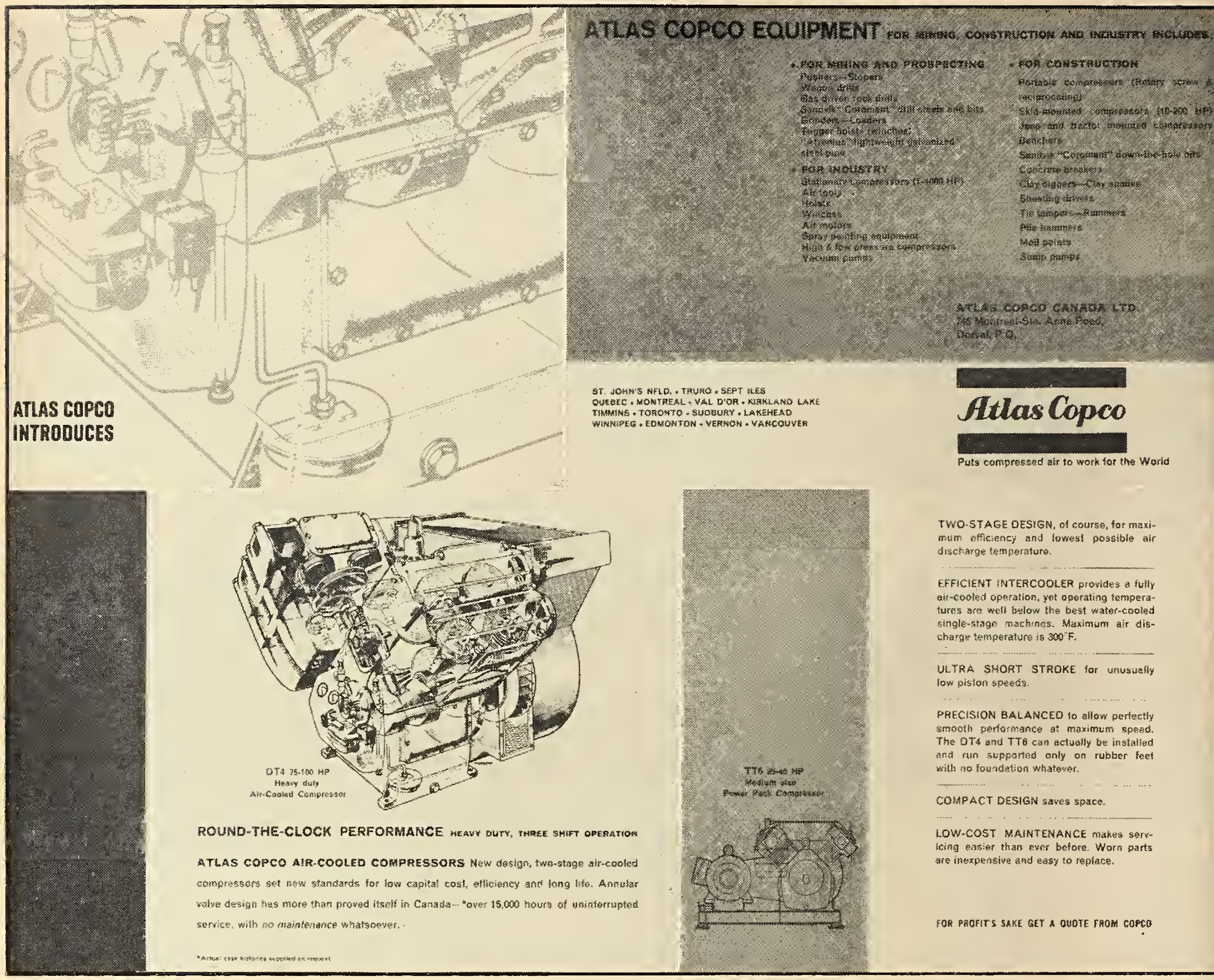
Edward E. Buswell has been appointed Technical Officer of the Canadian Institute of Timber Construction. He will be situated at the Ottawa office.

Frank H. Elliot has been appointed technical sales manager of the Industrial-Medical Division, Liquid Carbonic Canadian Corporation Limited. Mr. Elliot will remain in the Vancouver office where he was formerly regional sales manager for British Columbia.

R. Reid Scott has been appointed assistant manager of the pulp and paper instrument sales division of the Foxboro Company Limited, La Salle, Que. He will assist **F. L. Shonkwiler** in the direction of sales and application engineering in this field.

K. R. Revill has been appointed Manager of the Government and Industrial Department of Philco Corporation of Canada. **J. A. Price** has been appointed Sales Manager of the same department, and **T. I. Millen** as Manager of Development and Engineering.

Robert M. Jackson has been elected Chairman of the Board of Directors and Chief Executive Officer of Wallace and Tiernan Inc. This follows the retirement of **M. F. Tiernan** as Chairman. Mr. Tiernan was named Chairman Emeritus and **Robert T. Browning** was elected President to succeed Mr. Jackson.



ABOVE

Winner of the Monthly Award for the best advertisement in the November, 1961 issue of The Engineering Journal was Atlas Copco Canada Limited, Dorval, Quebec. The advertisement took the form of a horizontal half page 3-colour gatefold insert on heavy stock, and appeared facing page 16.

The cover of the insert used just three words to entice readers to open it — "Atlas Copco Introduces". Inside was a cut-away drawing of the new DT4 75-100 hp heavy duty air-cooled compressor. Copy was headed "Round-the-clock performance — heavy duty three shift operation" and emphasized the new design features.

Each month a different panel of fifty Journal readers from across Canada is asked to nominate an award-winning ad of their choice from the viewpoints of ACCURACY — INFORMATION — ATTRACTION. Winners and their advertising agencies receive a framed Certificate of Advertising Merit.

The advertising manager of Atlas Copco Canada Limited is Miss Jean Russell. The winning advertisement was prepared by the Montreal Office of F. H. Hayhurst Co. Ltd., W. S. Merrell, account executive.

(Continued from page 94)

*EVAPORATIVE COOLING OF CIRCULATING WATER.

Translated from the Russian revised edition, this volume gives an account of the theory, design, and use of cooling ponds, spray tanks, and other industrial coolers, utilizing data from Russian workers in the field and Soviet research. The first part of the book deals with the problems of heat transfer and mass transfer in evaporative cooling, and the theory and hydraulics of coolers. Part two describes the design of coolers, methods of calculations of cooling capacity, and operation and maintenance. (L. D. Berman. New York, Wiley, 1961. 392p., $20.00.)

*TEMPERATURE MEASUREMENT IN ENGINEERING, VOLUME II.

The first part of this volume is devoted to a systematic development of resistance-thermometry and radiation-thermometry techniques. The second part offers a detailed treatment of specific problems of temperature measurement, organized by situations, and the techniques most suitable for solving them. The situations examined include surface temperatures, rapidly changing temperatures, moving bodies, transparent bodies, liquids and gases, low temperatures, flame temperatures, and nuclear reactor temperatures. (H. D. Baker and others. New York, Wiley, 1961. 510p., $13.00.)

*BALLISTIC MISSILE AND SPACE VEHICLE SYSTEMS.

The disciplines involved in the development of a ballistic missile or space vehicle system are covered from an engineering viewpoint. The fundamental laws of propulsion, structures, trajectories, guidance and control are presented, and many of the interface problems which result when two or more of the subsystems interact are stated. The engineering design principles of each subsystem are discussed, and a survey of vehicle reentry stabilization and of vehicle support systems is presented. (H. S. Seifert and Kenneth Brown. New York, Wiley, 1961. 526p., $12.00.)

*FATIGUE TESTING AND ANALYSIS OF RESULTS.

After an introductory chapter on symbols and nomenclature, fatigue testing methods are fully described. Fatigue testing machines and equipment are then discussed, and include chapters covering instruments and measuring devices, the design, preparation, measurement, and protection of test pieces, factors affecting test results, planning of test programs, and presentation and analysis of results. (W. Weibull. New York, Pergamon, 1961. 305p., $15.00.)

GEARS: SPUR, HELICAL, BEVEL AND WORM, 2nd. ed.

Although called a second edition, this volume appears to have been produced by photo-offset, and any changes seem to consist of brief additions at the ends of chapters.

This well-known book covers the various types of gears in great detail, and includes many illustrations and diagrams. (P. S. Houghton. London, Technical Press, 1961. 390p., 63/-.)

(Continued on page 104)

(Continued from page 103)

MAGNETIC MATERIALS, 3rd. ed.

Enlarged, revised and partly rewritten, this edition has been converted to the rationalized m.k.s. system of units, and contains new information on domain theory and permanent magnetism, and a new chapter on ferrites. The bibliographies have also been brought up-to-date. This is a volume in the publisher's series of monographs on physical subjects. (F. Brailsford. London, Methuen, 190. 188p. 18/-.)

*SEVENTH NATIONAL SYMPOSIUM ON VACUUM TECHNOLOGY, 1960. TRANSACTIONS.

Over seventy papers are presented in this volume, which constitutes the proceedings of the Seventh National Symposium of the American Vacuum Society. They cover such areas as vacuum system components, vacuum measuring techniques, the apparatus and techniques of pressure measurements, industrial and metallurgical applications of vacuum, vacuum systems, their films, pumping mechanisms, and partial pressure measuring devices. (Ed. by C. R. Meissner. New York, Pergamon, 1961. 427p., $20.00.)

ARCHITECTURAL AND BUILDING CATALOGUE.

The catalogues of some fifty Canadian companies manufacturing building products, arranged according to the AIA/RAIC standard filing system. A classified list of products and their manufacturers is included, and an alphabetical list of manufacturers, their addresses, agents and distributors. These latter include many companies whose catalogues have not been included in the volume. (Montreal, Wallace, 1961. $10.00.)

*RADIO WAVES IN THE IONOSPHERE.

Based on annual lectures at the University of Cambridge, Dr. Budden's book is an advanced exposition of the mathematical basis of the theory of propagation of radio waves in an horizontally stratified ionosphere. The first half of the book deals with the "ray theory" — homogeneous ionized media and the reflection of high frequency radio waves at vertical and oblique incidence. The second half deals with the "full wave theory" — which is used when the ray theory fails: in the reflection of radio waves of very low frequency. To isolate fundamental methods as clearly as possible, the author excludes some important topics which deal with variables in practice, but do not alter fundamentals — such as recent investigations into horizontal variations and irregularities in the ionsphere, reflection and scattering of radio waves from meteor trails, and the mode theory of propagation. (K. G. Budden. Toronto, Macmillan, 1961. 542p., $16.50.)

COMMENTARY ON PLASTIC DESIGN IN STEEL.

Written by a Joint Committee of the Welding Research Council and the American Society of Civil Engineers, this Manual outlines the applicability of plastic analysis to the design of structural steel beams and frames, presenting both the theory and some of the design problems. The chapters cover basic principles; analysis and design; general provisions; the verification of plastic theory; design considerations; compression members; connections; deflections. A valuable eleven page bibliography is included. (New York, A.S.C.E., 1961. 173p., $7.00. A.S.C.E. Manual 41.)

L'ESSAI DES METAUX.

An introduction to metals testing, intended primarily for factory technicians and students, this text covers all types of testing. The first section deals with mechanical characteristics, tensile tests, and tests for creep, compression, bending torsion; shock testing, strength and fatigue tests. The second part of the book covers macrographic, micrographic and radiological tests, and the last section describes non-destructive testing. The volume is translated from the German. (P. Riebensahm and P. W. Schmidt. Paris, Dunod, 1961. 104p., 16 NF.)

LA TREMPE SUPERFICIELLE AU CHALUMEAU OXY-ACETYLENIQUE.

A detailed coverage of the surface hardening of metals by means of an oxy-acetylene pipe, commencing with a general discussion on the various processes for hardening metals, the choice of process, and the heat treatment of steel. The characteristics of the oxy-acetylene flame are noted, and the technique of hardening by this method, the materials used and the results. Two final chapters cover industrial applications. There is a useful bibliography. (M. Vilez. Paris, Dunod, 1961. 160p., 25 NF.)

LE NOYAU ATOMIQUE.

Translated from the 1955 U.S. edition, this is both a graduate text, and a reference book in fundamental nuclear physics. In considering each topic, the discussion begins at an introductory level, proceeding gradually to an advanced description of current research. The topics covered include nuclear and atomic masses; nuclear moments; the effects of nuclear moments, parity and statistics; isotopic abundance ratios; systematics of stable nuclei; forces between nucleons; nuclear models; conservation laws for nuclear reactions; energy dependence of nuclear-reaction cross sections; radioactive series decay; alpha- and beta-ray spectra. The author is a professor of physics at M.I.T. (R. D. Evans. Paris, Dunod, 1961. 752p., 84 NF.)

LES TRANSMISSIONS PAR CHAINES A ROULEAUX.

This discussion of roller chain drives is intended for both practising engineers and students. It covers the theory and practical considerations for choosing a chain drive, and compares different transmissions. Mounting and servicing are also considered, as are wheels and pinions. Much of the information is given in tabular form, and nomograms are also included. (P. Kuntzmann. Paris, Dunod, 1961. 220p., 42 NF.)

FLUID MECHANICS.

Intended for an introductory course in fluid mechanics, this volume emphasizes the concepts and principles of fluid motion common to applications in all branches of engineering. The book commences with a discussion of fluid statics, kinematics, and dynamics. Following chapters cover fluid viscosity, dimensional analysis, the flow of incompressible fluids in closed conduits, fluid compressibility and compressible flow, fluid flow around immersed bodies, dynamic lift, and the flow of fluids in open channels. (R. H. F. Pao. New York, Wiley, 1961. 502p., $7.50.)

QUALITY ASSESSEMENT OF PETROLEUM PRODUCTS.

Intended as an introduction to the interpretation of some of the more important tests applied to crude oil and its main products, this book is really a supplement to the compilations of Petroleum Products Standards issued by the Institute of Petroleum and the A.S.T.M. The various chapters, written by experts, cover crude oil; petroleum gases; petroleum solvents; motor gasoline; aviation fuels; diesel fuels; burning oil; fuel oils; lubricants; wax and petrolatum; and bitumen. Bibliographies are included in most chapters. (Ed. by George Sell. London, Institute of Petroleum, 1961. 123p., 15/-.)

MATHEMATICAL PROGRAMMING.

The author who works at the British Admiralty Research Laboratory, is well-known for his books on the subject of mathematical and linear programming. This text, intended as a graduate text, provides an introduction to linear and non-linear programming, emphasizing the mathematical aspects. In addition to outlining the basic theory, the author also covers general and special algorithms, the applications of programming, and more specific topics such as parametric linear programming, discrete linear programming, and stochastic linear programming. Problems and their solutions are included, and there is a useful bibliography. (S. Vajda. Reading, Addison-Wesley, 1961. 310p., $8.50.)

Consulting Services

Denotes Membership of a Principal in the Association of Consulting Engineers of Canada

Consulting Services

RACEY, MacCALLUM and ASSOCIATES LIMITED
A company owned and operated by
CONSULTING ENGINEERS
Civil, Electrical, Mechanical
Metallurgical, Soils
Engineering
MONTREAL TORONTO OTTAWA

RIPLEY, KLOHN & LEONOFF LTD.
Consulting Engineers
SOIL MECHANICS AND
FOUNDATIONS
1930 WEST BROADWAY VANCOUVER 9, B.C.

S. E. M. PROSPECTING LIMITED
Depth to bedrock determination by the
SEISMIC REFRACTION METHOD
for
Dam and Power Station locations: Rock Tunnels:
Harbour Constructions and Canals: Larger
Building Sites, etc., etc.
506 St. Catherine Street E., Montreal 24
Phone: VIctor 9-9252

Stadler, Hurter
& Company
CONSULTING ENGINEERS
Municipal, Commercial, Industrial,
Process and Power, Engineering
and Design.
1501 St. Catherine Street West, Montreal
NEW YORK • MEXICO CITY • PARIS • ZURICH

STOCK, KEITH & ASSOCIATES
Architecture and Engineering
Foundation Investigation and Design
Industrial & Structural Engineering
Roads, Irrigation & Drainage
Legal Surveys
766 Angus Street, REGINA, SASK.
Telephone JOrdan 9-0626

SWAN, WOOSTER ENGINEERING CO. LTD.
CONSULTING ENGINEERS
HARBOUR WORKS • INDUSTRIAL PLANTS • BRIDGES
HYDRO-ELECTRIC • STRUCTURAL DESIGN
Surveys • Reports • Design • Supervision
1334 W. Pender St. Vancouver 5, B.C. — 520 S.W. Yamhill St., Portland 4, Oregon. — 1685 Third Ave., Prince George, B.C.

B. B. TORCHINSKY & ASSOCIATES LTD.
PROFESSIONAL CONSULTING ENGINEERS
- Foundation Site Investigations
- Highway Design & Inspection
- Materials Testing Laboratory
- Asphalt Mix Designs
- Concrete Testing & Inspection

Drilling Rigs Located Throughout Western Canada
HEAD OFFICE
SASKATOON, SASKATCHEWAN
121 - 105th ST. EAST
REGINA EDMONTON WINNIPEG

VANCE, NEEDLES, BERGENDOFF & SMITH, LTD.
CONSULTING ENGINEERS
EXPRESSWAYS • BRIDGES • AIRPORTS
Location and Cost Studies, Designs, Plans, Specifications
Supervision of Construction
35 SPRINGBANK AVE. WOODSTOCK, ONTARIO

W. L. WARDROP & ASSOCIATES
(Management) Ltd.
ENGINEERING CONSULTANTS
Design and Inspectional Services for
Municipal, Structural, Mechanical
and Electrical Engineering Projects.
456 Notre Dame Avenue, Winnipeg 2, Manitoba.
47 N. Cumberland Street, Port Arthur, Ontario

THE WARNOCK HERSEY COMPANY LTD.
Consulting, Inspection, Expediting, Testing.
Mechanical, Electrical, Civil Inspections • Soil Mechanics and Site Investigations • Chemical and Physical Tests • X-Ray and Ultrasonic Examinations • Research • Industrial Appraisals and Surveys • Expediting.
Head Office: 128 Elmslie Street, Montreal 32, P.Q.
Branch offices: St. John's, Nfld., Sydney, Halifax, Trenton, N.S., Saint John, N.B., Montreal, Ottawa, Peterborough, Toronto, Hamilton, London, Windsor, Sault Ste. Marie, Winnipeg, Regina, Edmonton, Vancouver.

WIGGS, WALFORD, FROST & LINDSAY
Consulting Engineers
INDUSTRIAL SURVEYS, REPORTS AND APPRAISALS
CIVIL, ELECTRICAL AND MECHANICAL ENGINEERING
DESIGNS, SPECIFICATIONS AND SUPERVISION
TORONTO HUdson 1-6496 — MONTREAL HUnter 1-7741 — OTTAWA CEntral 6-5371

WOOD, McADAM & MAGOR
Consulting Engineers
STRUCTURAL - MECHANICAL - ELECTRICAL
DESIGNS, SPECIFICATIONS and SUPERVISION
4444 SHERBROOKE ST. WESTMOUNT, P.Q.
WE: 5-8587-8588

Denotes Membership of a Principal in the Association of Consulting Engineers of Canada

INDEX TO ADVERTISERS

FEBRUARY 1962

PUBLICATION OFFICES: The Engineering Institute of Canada, 2050 Mansfield Street, Montreal 2, Quebec, Canada.

Association of Consulting Engineers of Canada Incorporated

The following firms have principals who are members of this Associatio engaged as professional engineers in engineering work independent o salaried employment or sales promotion.

The revenue derived from the sale of advertising space assists the Institute in publishing THE ENGINEERING JOURNAL on a regular monthly basis. Listed above are the names of the Companies and individuals whose advertisements appear in this issue.

ADVERTISING OFFICES

QUEBEC: J. E. Donovan, Manager, Advertising Sales—D. W. Campbell, 2050 Mansfield Street, Montreal, Phone: VIctor 2-8121
ONTARIO: L. G. Barnum, Manager, Advertising Sales, 160 Eglinton Ave. E., Suite 103, Toronto, Phone: 485-0789
VANCOUVER: Eric Lindsay, 545 Thetford Place, West Vancouver, B.C. WAlnut 2-1415
MANITOBA: W. George Turner, 501 - 191 Lombard Ave., Winnipeg, Man., WH 3-9123
EUROPE: H. A. Mackenzie, 4A Bloomsbury Square, London, W.C.1, England. Phone: HOlborn 3779
NEW ENGLAND STATES: R. G. Melendy, 17 Maugus Avenue, Wellesley Hills 81, Mass. Phone: CEdar 5-6503
CHICAGO: W. Reynold Ratz, 549 W. Randolph St., Chicago 4, Ill. Phone: ST-2-8811
NEW YORK: John H. Boyd, 17 East 45th Street, New York, Phone: MUrray Hill 7-0654

EIC

President
B. G. BALLARD, HON. M.E.I.C.
Treasurer
E. JUBIEN, M.E.I.C.
General Secretary
GARNET T. PAGE, M.E.I.C.

THE
ENGINEERING JOURNAL
VOLUME 45 NUMBER 3 MARCH 1962

ISHED MONTHLY BY THE ENGINEERING INSTITUTE OF CANADA, 2050 MANSFIELD ST., MONTREAL 2, QUE., CANADA • TEL. VI. 2-8121

Editor
GARNET T. PAGE, M.E.I.C.
Associate Editor
G. LA FONTAINE
Production Supervisor
M. V. KAY
Manager of Advertising Sales
JOHN E. DONOVAN
Advertising Offices listed in Advertisers' Index
Circulation Supervisor
ROBERT G. HUNGATE

PUBLICATION COMMITTEE
Chairman: R. A. Phillips, M.E.I.C.
Members: B. O. Baker, M.E.I.C.
D. J. McDonald, M.E.I.C.
N. B. Hutcheon, M.E.I.C.
J. S. Walsh, M.E.I.C.
W. H. Gauvin, M.E.I.C.
P. Duchastel, M.E.I.C.
W. Bruce, M.E.I.C.
G. V. Meagher, M.E.I.C.
I. D. MacKenzie, M.E.I.C.
ex officio: D. L. Mordell

Printed in Toronto

rice $6.00 a year in Canada, British ossessions, United States and Mexico, 7.50 a year in Foreign Countries. Current sues, 75 cents a copy, back issues from 1.00 per copy up. To members, affiliates nd other bona fide engineers in Canada— o charge. Authorized as second class mail, y the Post Office Department, Ottawa, nd for payment of postage in cash.

MEMBERSHIP

CCAB BNA

Indexed in
The Engineering Index
The Applied Science and Technology Index

CONTENTS

IN THIS ISSUE

The Rogers Pass section of the Trans Canada Highway is threatened by numerous avalanches which are mainly the result of the heavy amount of snowfall and the steep, long mountainsides. In 1953, at the same time when the highway was first studied, an avalanche survey was organized to obtain information required for the formulation of an avalanche defence plan, for the design of avalanche defence structures and for the future avalanche warning service. In his paper entitled, ***"The Planning of Avalanche Defence at Rogers Pass"***, **P. A. Sehaerer**, M.E.I.C., of the Snow and Ice Section, Division of Building Research, National Research Council, Ottawa, describes the observations that were made and how they were used for the formulation of an avalanche defence plan. The various possible defence methods are discussed and the defence chosen for Rogers Pass is outlined.

When designing the Beechwood hydro electric power station on the St. John River, it was imperative that adequate fish handling facilities be provided to transfer fish from below the dam up to the forebay of the development. The elevator fish hoist selected for this purpose was developed in close co-operation with the Department of Fisheries and realized substantial economies in construction over the alternative facilities considered for the site. In his paper, ***"The Beechwood Fish Hoist"***, **J. D. Denovan**, M.E.I.C., the Assistant Office Engineer, Civil Division, at Shawinigan Engineering Company Limited, describes the general conditions affecting the selection of facilities and the factors establishing the criteria for design. The paper describes the fish handling facilities, in particular the fish hoists, which were installed at the Beechwood Development, and relates some of the operating experience since these facilities were placed in service. Modifications to the facilities resulting from this operating experience are also considered.

Thrust bearings composed of flat parallel surfaces can operate under fluid film conditions by the formation of a 'thermal wedge'. **John Young**, Assistant Professor, Department of Mechanical Engineering at the University of British Columbia, in his paper, ***"The Thermal Wedge Effect in Hydrodynamic Lubrication"*** solves in three ways the general Reynolds equation and the energy equation which govern the thermal wedge mechanism, illustrating the effect of certain initial assumptions in the analysis. The experimental results presented are shown to be in fair agreement with derived curves, showing that while the thermal wedge does exist, and is appreciable at low loads and high speeds, it cannot be depended upon to provide a load-carrying film in normal lubrication practice.

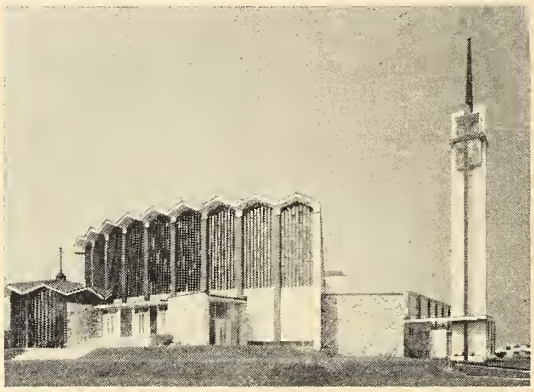
Dr. B. G. Ballard, Hon. M.E.I.C., Vice-President (Scientific) and Director, Radio and Electrical Engineering Division, National Research Council, Ottawa, states in his paper entitled, ***"A Research Viewpoint on Engineering Education"*** that Canadian engineers have served Canada well in the development of her primary industries. Some engineers came to Canada from Europe and the United States, but Canadian universities very early initiated engineering training, and many of the men who contributed so much to Canada's growth were born and trained in Canada. The pattern has changed in recent years. Canada emerged from colonial status and became an industrial nation in a highly competitive world. The future demands men with new ideas, men who are imaginative enough and creative enough to make the best use of our resources. They must have adequate training and encouragement to develop their creative talents, and these requirements delineate the role of the universities.

Universities can no longer be content only to impart to students the accumulated knowledge of the past. They must lead the way in creating new design techniques and new processes. Research must be looked upon as an essential element of university life rather than as an extra-curricular luxury financed by some benevolent organization. We need schools to impart knowledge of the past, but we need universities to develop knowledge of the future.

"Recent Developments in Automatic Electrode Boilers" is the title of a paper by **M. Eaton**, M.E.I.C., Consulting Engineer of Shawinigan, Que. A main object of the development discussed in this paper, was to produce an electrode boiler well suited to the use of off-peak hydro-electric power. For this application essential requirements are: (1) operation at any distribution voltage from 2.2 kv to 13.2 kv, thus obviating the necessity for power transformers to serve the boiler only, unless separate boiler transformers are required for other reasons; (2) a load range of from practically no load to full load, and; (3) stable and precise automatic control which will function to maintain a constant load on a system of which the boiler load is part. It follows that a boiler with these characteristics may also be used as a source of steam at constant pressure with the load control apparatus functioning to maintain a predetermined maximum boiler load. This paper includes a study of electrical characteristics on which the boiler design is based.

COVER ILLUSTRATION

Shown is an avalanche site Cheops No. 1 with earth mounds in the terminus. This photograph was taken by Bruno Engler and is used with the permission of the Federal Department of Public Works.



Planning

AVALANCHE DEFENCE

For The Trans-Canada Highway

AT ROGERS PASS, B.C.

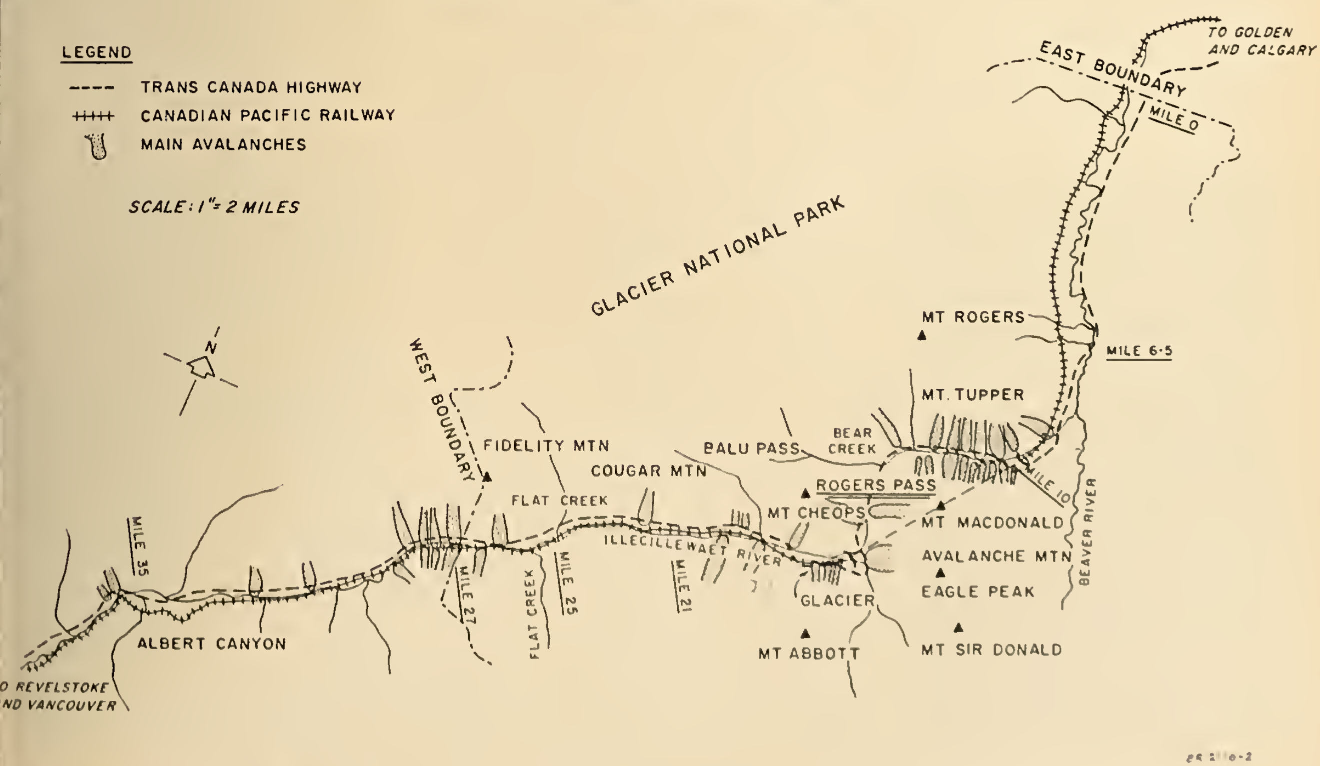
P. A. Schaerer

Former Research Officer, Snow and Ice Section, Division of Building Research, National Research Council, Ottawa

THE SELKIRK Mountain range in the interior of British Columbia one of the major obstacles to be rossed by the Trans-Canada High-ay. Various routes through this inge have been investigated; that rough Rogers Pass was selected.[1] he pass lies between the towns of olden and Revelstoke in Glacier ational Park and was chosen by the anadian Pacific Railway as the route for the first railway link between Eastern Canada and the Pacific Coast. It was in use from 1885 until 1916 when the Connaught tunnel was built and the railway line through the Pass was abandoned.

It was known that avalanches would be one of the major problems for any road built through the Selkirk range (Fig. 1). Accordingly, in 1953 the Department of Public Works of Canada, which is responsible for the construction of the Trans-Canada Highway through Glacier National Park, began reconnaissance work for the highway and organized a preliminary survey of avalanche sites and avalanche activity. These avalanche observations were under the direction of N. C. Gardner. In 1956 an avalanche observation station was established to carry out the more detailed

Figure 1: Rogers Pass with main avalanches.



study of avalanche activity required for the design of the defence system. The National Research Council, through its Division of Building Research, co-operated in the organization of the avalanche observation station. Between 1957 and 1960 the author was in charge of this station and was responsible for planning the avalanche defence. This paper describes in brief the observations which were made and summarizes the defence which was chosen.

Figure 2: Bear Creek valley on the east side of Rogers Pass. Part of the highway can be seen in the left foreground.

Terrain

The summit of Rogers Pass is 4,300 ft. above sea level, and the peaks of the Selkirk range rise to 11,000 ft. The valleys associated with the Pass are short and comparatively steep on the east side, but rise to the summit with a gradual climb from the west. A typical Selkirk valley is narrow and has steep sides (Figs. 2, 3).

The mountain sides on the Rogers Pass route have a terrace located between 5,500 and 6,500 ft. above sea level (Figs. 4, 5). The terrace goes gradually over into the scree slopes and rockfaces which rise to the mountain ridges. Below the terrace a sharp drop over cliffs leads to talus slopes and alluvial fans into the valley bottom which is between 300 and 1,000 ft. wide. In some places the mountain sides are close together, resulting in a narrow V-shaped valley. The highway is cut into the talus slopes and alluvial fans, and except for two short sections is located on the north side of the river which flows through the valley. The lower mountain sides and valleys are covered with heavy timber and dense brush. Trees become scattered on the terrace, leaving space for alpine meadows.

Figure 3: Illecillewaet valley on the west side of Rogers Pass. The avalanche sites are the open paths on both sides of the valley.

Climate

Rogers Pass is in the region popularly known as the interior wet belt of British Columbia.[2] High annual precipitation and heavy snowfall are its most distinctive features. The average annual precipitation, measured between 1921 and 1950, at Glacier close to the summit of Rogers Pass, is 18 in. of rain and 342 in. of snow, while the maximum annual snowfall ever observed was 680 in., measured during the winter 1953-54. The magnitude and frequency of the 24-hour snowfalls at Glacier during the winters between 1953 and 1960 are shown in Table I.

Storms with a high rate of snowfall are not frequent and are usually of short duration. A day with heavy snowfall is usually followed by one or several days with only light snowfall. During winters of light snowfall three storms may occur yielding more than 16 in. of snow in a three-day period, but during winters of heavy snowfall 10 such storms may occur. Only occasionally, about once in three years, is there a snowstorm that contributes more than 36 in. in a three-day period. Most snowfalls are accompanied by wind which deposits large amounts of snow on the lee side of the mountain ridges. The maximum depth of snow on the ground in the valley is about 100 in., and on the mountain, at the 6,700-ft. level, the greatest measured depth of 160 in. was observed on May 1, 1959.

Temperature during a snowstorm normally ranges between 20 and 32°F. After the storm has ended, it is usual for cloudy weather to continue and the temperature to change relatively slowly. Frequently, however, the temperature rises during a snowstorm and the snowfall in the valleys changes to rain. The temperature falls

TABLE I

Frequency of Snowfalls at Glacier

Winter	*Number of days with snowfalls* Less than 4 in.	4 to 12 in.	12 to 20 in.	20 in.	*Total snowfall for the winter, in.*
1953/54.........	56	44	7	2	680
1954/55.........	35*	17*	—	—	310
1955/56.........	42	30	—	—	336
1956/57.........	47	17	3	1	341
1957/58.........	74	26	1	—	321
1958/59.........	85	41	3	—	442
1959/60.........	84	29	1	—	368

*The records of the winter 1954/55 include only the snowfalls after 1 January 1955.

elow 0°F only a few times during e winter and this cold weather usu- ly does not continue for more than week.

valanche Survey

The avalanche survey had to oduce the following information out the average and very large alanches that occur at each site: eir rupture zone, path and terminus; eir depth and width; eir frequency of occurrence; e prevailing conditions responsible r their occurrence.

formation was obtained by monthly trols through the area during the st three years, and after 1956 by ily and weekly patrols to record servations on each avalanche that curred, even on those which ter- inated far from the highway. The pture zone and path of important alanches was sketched on photo- aphs and all avalanches that de- sited snow near or on the highway ght-of-way were traced on location lans. Information on the conditions at cause avalanches was obtained rough snow cover and weather ob- rvations at four observation sites the valley and two mountain ob- rvatories located at an elevation of bout 6,800 ft. Precipitation and tem- erature measurements made at Gla- er previous to 1953 were available om the Meteorological Branch of the epartment of Transport.

he avalanche survey was completed y site studies in summer and winter. xtent, slope angle, exposure, soil onditions, age of trees in the rupture one, path and terminus were ob- rved at each site. Valuable infor- ation was also obtained from the anadian Pacific Railway Company, who kindly made available their rec- ords on all avalanches that had af- fected railway operation during the period 1910 to 1952.

In 1960, when the final plans were developed for the first stage of de- fence, there were available detailed observations of avalanche activity during seven winters and partial ob- servations from another 40 years. Records of avalanches that occurred during the years before 1953 re- vealed that there were periods of more than one year in which avalanche ac- tivity was a maxium. These periods of maximum activity are associated with periods of high snowfall and high temperature. Unfortunately, the present survey was conducted during what the records indicate to be a period of low activity, both as to the size and the number of avalanches. Observations taken do not, therefore, cover the worst possible conditions which may be encountered. The sur- vey did produce a good picture of avalanches that may be encountered during an average year, but maxi- mum conditions had to be deduced from the few large avalanches that occurred during the observation peri- od and from the incomplete observa- tions of earlier years.

igure 4: Avalanche site Cheops No. 2.

Avalanche Sites

Avalanche sites can be easily recognized by the scars on the tim- bered mountainside (Fig. 2). The area where avalanches start to slide and where the bulk of snow origin- ates is called the rupture zone. The previously described terrace at an elevation of about 6,000 ft. divides the rupture zone in many of the avalanche sites. The avalanches rup- ture in a lower zone on or at the toe of the cliffs below the terrace or in an upper zone on the steep slopes rising to the mountain ridges (Fig. 5). Many of the small avalanches which originate in the upper zone stop on the terrace. Large avalanches overrun the terrace and gain a high speed as they fall over the steep slopes below. There is evi- dence that many lower rupture zones at Rogers Pass were once covered with timber that prevented the occurrence of avalanches. Fires appear to have removed these trees and destroyed a very effective natural defence.

The avalanche path is the track fol- lowed by an avalanche during its de- scent. The majority of avalanches at Rogers Pass are confined in gullies which have been carved in the moun- tains by running water (Fig. 5). A few avalanches reach the valley over open, bare slopes (Fig. 4). The ter- minus is the area where the main body of the avalanche comes to rest.

Figure 5: Avalanche site Tupper No. 2. The rupture zone is at the cliffs and snowfields below the mountain peak; the gully is the avalanche path and the terminus of the avalanche is on the wide alluvial fan. The terrace is above the cliffs with the waterfall.

Avalanches slow down on the alluvial fan or the talus slope at the lower part of the mountain. Minor ones will stop there but major avalanches ad- vance into the valley and in some cases reach the opposite side.

The narrow valley in Rogers Pass and the fact that avalanches reach the valley floor from both sides made it impossible to construct a highway that would avoid all dangerous sites. In the 35-mile highway section be- tween the east boundary of Glacier National Park and Albert Canyon on the west side 74 avalanche sites had to be crossed; 61 of these lie within the Park. As the avalanches do not occur under the same conditions at each site, and since the topography and area of the rupture zones and the avalanche paths may produce ava- lanches of different sizes, the hazard to the highway varies from one ava- lanche site to the next.

The 74 avalanche sites can be class- ified as follows:

Nine sites where minor and major avalanches occur frequently and where at least one major avalanche can be expected to reach the high- way every year;

Twenty-one sites where minor avalanches occur frequently and usu- ally reach the highway once or more than once each winter; the mass of the sliding snow is small and may not cover the whole width of the highway; large avalanches occur occasionally but not every winter.

Thirteen sites where avalanches occur only under severe conditions and not more frequently than once in two years; the avalanches may deposit a large amount of snow on the highway,

Thirty-one sites where avalanches occur only under severe conditions and not more frequently than once in two years; the snow that would reach the highway from these avalanches would usually be airborne and little would be deposited on the highway.

The most active avalanches are concentrated in a narrow defile, about 2½ miles long, between Mt. Tupper and Mt. MacDonald. Here the concentration of sites is so great that they merge into an almost continuous slide belt (Fig. 1). Another section with active avalanches is just outside the western boundary of Glacier National Park. Between and outside these two areas the avalanche paths are more scattered.

Classification of Avalanches at Rogers Pass

Avalanche classifications have been suggested by various authors since avalanches were first described in the late 19th century.[3] Each classification serves a particular purpose, e.g. a skier travelling in the rupture zone may look at the avalanches from a viewpoint different from that of the engineer who is only concerned with the effect the moving avalanche has on structures. The following classification, which uses the cause of avalanches as a basis, proved to be most practical for the design of the defence system at Rogers Pass.
The frequency of occurrence and the proportion of the avalanches in each class was determined for each site and the defence chosen accordingly.

Dry Snow Direct Action Avalanches

The majority of all avalanches fall into this category. They occur during or immediately after a snowstorm, and avalanche hazard can be recognized by observing the snow cover and the weather. Minor avalanches may reach the highway after snowfalls of 10 in. when accompanied by wind. Experience has shown that snowfalls of two to three days' duration, yielding more than 16 in. of new snow and accompanied by strong wind, or 22 in. without wind, may cause an avalanche hazard at all known sites. This amount of new snow is only a general guide; an unstable snow cover, low temperatures or other influences may cause avalanches before this amount has been reached. A continuous snowfall, exceeding 30 in. of new snow, may cause unusually large avalanches. Dry snow avalanches move on the surface and are accompanied by a cloud of snow dust. The avalanche may become airborne over cliffs or very steep terrain and the cloud of snow dust obtain a high speed. Some avalanches may deposit large amounts of snow on the highway; others may cause only strong windblast and deposit light snow.

Wet Snow Direct Action Avalanches

These avalanches occur when snowfalls are followed immediately by rain or warm weather. They can be large and reach the highway when the snowfall exceeds 12 in. The wetter the snow the more the avalanches move on the surface, with little or no dust cloud and accompanying windblast. Records of the railway company indicate that most of the big avalanches which have blocked rail traffic for long periods of time were the result of heavy snowfalls followed by warm weather. It would appear that major occurrences of wet snow direct action avalanches would create the most unfortunate situation for the highway, because the avalanches could cover the highway with deep snow simultaneously at many sites (Fig. 6).

Dry Snow Delayed Action Avalanches

These avalanches are also called climax avalanches, and are caused by various factors which build up the avalanche hazard over a period of time during which snowfall does not necessarily have to occur. By careful observation of the snow cover and the weather it is possible to evaluate the avalanche hazard and determine the periods when such avalanches may affect the highway. These avalanches have the same effect as dry snow direct action avalanches, but unlike that class appear to occur sporadically and do not normally affect large sections of the highway simultaneously.

Spring Thaw Avalanches

These avalanches occur as a result of the loss of cohesion of snow as it melts. They usually occur in cycles at many sites simultaneously during a few hot days, but single occurrences were observed also. The avalanches can involve large masses of wet, heavy snow and often slide on the ground. They usually have a lower speed and a smaller range than the dry snow avalanches, and tend to flow in channels.

Avalanche Defence Methods

From the observations made on avalanches and their causes, it was necessary to formulate a general defence plan for the whole route, and to indicate the defence method that should be applied for each avalanche site within the general plan. To the greatest possible extent the Trans-Canada Highway was constructed through areas safe from avalanches. When an avalanche path could not be avoided, attention was given to locating the highway in such a way as to reduce the effect of the avalanches, e.g. placing the highway near the tip of the avalanche terminus where it would be reached infrequently by avalanches or high on the mountainside where the avalanche path is narrow and snow clearing to the downhill side easier. Cuts were daylighted in order to avoid deep snow deposits.

Much valuable experience is now available from countries such as Switzerland, Austria and the United States on various methods of defence against avalanches.

Active Defence

- Structures and vegetation (permanent measures)
  - Retaining barriers
  - Snowfences and windbaffles
  - Braking barriers: Earth mounds, Catching dams
  - Diverting dams
  - Snowsheds
  - Reforestation
- Explosives (temporary measures)

Avalanche Class	Main Cause
Dry snow direct action avalanches	snowfall, wind
Wet snow direct action avalanches	snowfall in association with rain or temperatures above 32°F
Dry snow delayed action avalanches	unstable snow cover, snowfall and wind over a long period of time.
Spring thaw avalanches (or wet snow delayed action avalanches)	high temperatures

Passive Defence

Avalanche warning (temporary measure)
Highway closures
Avalanche detection

All methods may be applied alone or in combination. They are described below and rationalized for the defence at Rogers Pass.

Retaining barriers are constructed in the rupture zone and control avalanches at their source. They can create a completely safe site. It was found that costs for barriers in the remote and large rupture zones which occur at Rogers Pass were prohibitive. Retaining barriers could be built economically only at minor avalanche sites where the rupture zone is close to the highway, e.g. on long, steep banks from which significant amounts of snow may slide and cover the highway.

Figure 6: Terminus of a wet snow direct action avalanche on the future highway. The snow is 45 feet deep.

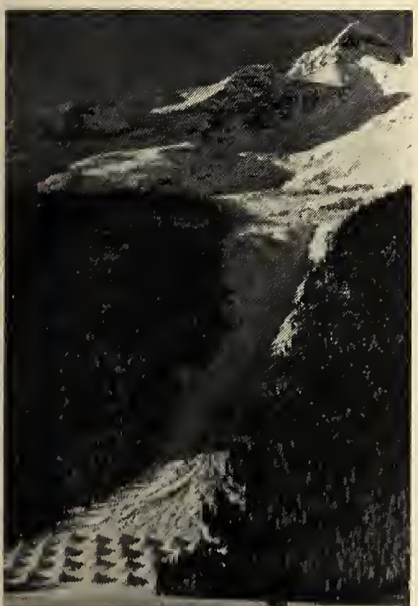


Figure 7: Avalanche site Cheops No. 1 with earth mounds in the terminus.

Snowfences and windbaffles control in the rupture zone the drifting snow that may create an avalanche hazard. It was considered that this defence is not suitable for Rogers Pass, because the structures must be built at high elevations and on exposed mountain ridges where construction and maintenance are difficult. This defence does not prevent dry or wet snow direct action avalanches that are not accompanied by wind. Furthermore, it is possible that deep snow would soon cover the structures.

Braking barriers are obstacles in the avalanche path which slow down or stop the avalanches before they reach the highway. Of the various structures which can be used, earth mounds and catching dams were judged to be suitable.

Earth mounds are built in two or more rows in a checkered arrangement on the flat section of the path where the avalanches would normally have slowed down considerably (Figs. 7, 8). At Rogers Pass, the alluvial fans at the terminus of the avalanche sites have low slope angles and are a suitable location for mounds. A series of experimental mounds was constructed in 1957. Observations during the following three winters showed that at locations where the mounds were constructed dry snow avalanches were slowed down while passing between the mounds and terminated just beyond; spring thaw avalanches stopped at the first row of mounds. It was decided that mounds should be built as defence against wet snow avalanches and smaller dry snow avalanches at other sites where not more than three avalanches per winter are likely to occur. Because construction costs are low, they can be built as defence against large dry snow avalanches also. In this case, it is not expected that the mounds will stop the avalanches completely, but they should retain a great part of the heavier sliding snow and reduce the

Figure 8: Earth mounds with deposited avalanche snow.

dimension of the avalanche on the highway. The mounds built at Rogers Pass are 15 to 25 ft. high with a distance of 60 to 80 ft. between centres. The number of mounds and their size depends on local conditions such as normal size of avalanches and nature of terrain.

Catching dams are built perpendicular to the avalanche direction. Their efficiency is limited because fast-moving avalanches can jump over them and the spaces behind are often filled with snow after one avalanche has occurred. It can easily be calculated that a catching dam requires about the same earth quantity as two rows of mounds of equal height. Mounds, however, are more efficient in stopping avalanches. It was considered that dams could be built at Rogers Pass immediately above the highway where not more than two avalanches are likely to occur and where there is insufficient space for construction of mounds. Catching dams are between 10 and 15 ft. high. During the two winters between 1957 and 1959, tests were made with catching dams built by pushing snow to the outside edge of a wide terrace. These proved effective against small avalanches, but since snow dams have to be rebuilt each winter earth dams were considered more practical.

Diverting dams divert an avalanche laterally to an area where it can run out harmlessly. Use of small dams with a natural earth slope or a vertical wall on the side facing the avalanche was considered for different avalanche sites where they could be built easily on the long alluvial fans. It was concluded, however, that if these dams were constructed in the terminus zone of the avalanches they would be backfilled by early snow deposits and prove ineffective for later avalanches. Furthermore, it was found that earth mounds produce the same degree of protection as earth dams at lower cost. In two cases, even a snowshed proved to be less expensive than the required long and high dam.

Diverting dams with modified function are used in association with snowsheds. In this case the dams restrict the spreading of the avalanches and keep them in a defined straight path. Such dams were once built on Rogers Pass in association with the numerous snowsheds which protect the railway. Remains of the dams, consisting of stone-filled log cribs, can still be found along the abandoned railway line. But construction methods have changed during the past 70 years, and for the highway it proved more economical to construct high dams with a natural earth slope to reduce the width of the avalanches and minimize the length of the snowshed (Fig. 9). These dams are 20 to 25 ft. high. For some sites, where frequent avalanches occur during the winter, it was possible to increase the effective height of the dams by excavating a channel in the avalanche path. The excavated earth was used for highway fill.

Snowsheds divert moving avalanches over the highway. Expensive structures, they were considered only for sites where other active defence methods proved to be inadequate (Fig. 10). At Rogers Pass the highway must cross most avalanche sites in the terminus zone, and loads from deposited snow can be very large. For three winters, therefore, snow depth, slope angle and density of deposited avalanche snow were surveyed in sites where sheds are planned. The static load for each snowshed was estimated from these observations. The largest design static load was calculated to be 1100 p.s.f. on the uphill side of the snowshed and 500 p.s.f. on the downhill side. This corresponds to a snow depth of 29 ft. and 13 ft. respectively, with an assumed average snow density of 38 lb/cu ft. The shed must also be designed to withstand the forces produced by a moving avalanche. For one site this dynamic force was calculated to be 700 p.s.f. vertical load and 350 p.s.f. lateral force due to friction. Lighter sheds, to be built in the path of smaller avalanches, were designed for deposit loads of 450 p.s.f. and 150 p.s.f. and 300 p.s.f. moving load. A paper giving detailed information on the design of snowsheds is being prepared.

Reforestation in the rupture zone serves the same purpose as retaining barriers. Reforestation projects must be associated with temporary retaining barriers, which because of expense were not considered for Rogers Pass.

Explosives are a temporary defence measure that is cheap and versatile. When the avalanche hazard dictates avalanches can be released under control by detonating explosives in the rupture zone. Under certain circumstances, particularly when there is a hazard for dry snow delayed action avalanches, the explosion can create a stable snow cover without producing an avalanche. Much experience on this method of ava-

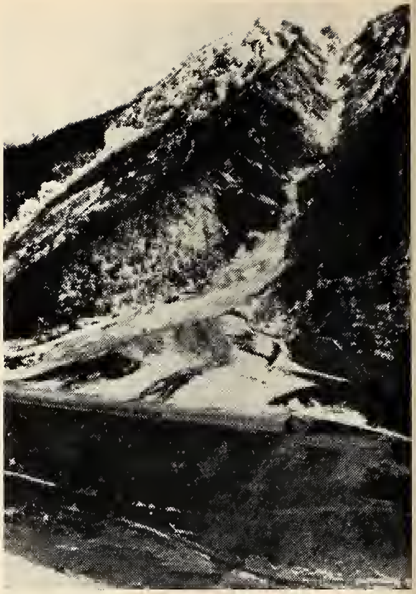


Figure 10: Snowshed in the Lanark avalanche site. The snowshed was built in 1960 by the B.C. Department of Highways.

Figure 9: Diverting dams which confine the width of the avalanches. A snowshed will be built in the path of the avalanches.

lanche defence has been gained in the U.S.A. and in Switzerland, where it has proved effective and economical against direct action avalanches and dry snow delayed action avalanches, although not against spring thaw avalanches.

The normal technique is to use projectiles fired from an artillery weapon. Studies and experiments indicated that the 75-mm. and 105-mm. howitzer are most suitable for avalanche control at Rogers Pass. Some rupture zones are too rugged for economical firing and at a few avalanche sites no suitable firing position could be found. Since firing must often be done during snowstorms when maintenance personnel are already busy with snow removal work, and because a large portion of the highway is in the National Park which should not be converted into an artillery range, it was decided that artillery fire should be used only against avalanches that cannot be controlled economically by other methods. Hand-placed and preplanted explosive charges were found unsuitable at Rogers Pass because of the remoteness of the rupture zones.

Highway closure for the duration of dangerous avalanche conditions is a simple protective measure. It requires an organization to study snow cover and weather, evaluate avalanche hazard and order closure and reopening as necessary. It was considered that although the Rogers Pass route must be open for the whole winter, short closures would be permissible.

An avalanche detection system consists of an electronic device which detects an avalanche as it occurs and operates warning signals. In a long path, an avalanche may be detected some time before it reaches the highway and traffic signals could warn oncoming vehicles before they enter the dangerous area. In short paths the device may only signal avalanche occurrence to the maintenance headquarters. The former use of the system may be feasible at a later stage of defence at a few selected avalanche sites at Rogers Pass, but the latter use of the system was chosen for two sites where frequent small avalanches may cover the highway. The Radio and Electrical Engineering Division of the National Research Council has built an avalanche detection device for Rogers Pass that is now being tested.

Avalanche Hazard Evaluation and Prediction

Defence by means of explosives and highway closure requires the evaluation of avalanche hazard to determine when explosives should be used and when the highway must be closed or reopened. An avalanche is caused by different factors associated with terrain, snow cover, snowfall, wind and temperature, all in close relationship. Certain rules have been established through experience on the dependence of avalanche hazard on these factors. Hazard can be evaluated quite accurately for the time of observation, but the prediction of future hazard is only as good as the weather forecast. In practice, the avalanche hazard forecaster has to assume that weather will follow a certain pattern and his prediction is based on this. The evaluation of the avalanche hazard can be approached by two different methods, called here the testing method and the analytic method.

The testing method has been developed in Switzerland;[4] evaluation of the avalanche hazard is based on snow cover observations. Stability of a snow cover can be tested directly from time to time and weather factors such as snowfall, wind and temperature used to determine its stability between observations. With experience and tests, it has been found which factors may lead to a fracture and which conditions contribute to stabilization.

The analytic method is the technique used in the U.S. Forest Service.[5] Most avalanche sites with which this service was concerned produced direct action avalanches. Observations over a few winters indicated the weather and snow cover factors mainly responsible for creating them. By determining the magnitude of each factor, it was possible to evaluate avalanche hazard. This method requires more accurate weather observations than the testing method, but produces better results.

In practice, both methods are used in combination. Between 1956 and 1959 observers at the avalanche observation station in the Rogers Pass area made snow cover and weather observations and evaluated daily the avalanche hazard. The testing method was used as the basis for evaluation. Weather conditions that caused avalanches at specific sites were analysed and rules for forecasting direct action avalanches were found. Other studies were made to establish a rule of thumb for the hazard evaluation of spring thaw avalanches. In 1959 the responsibility for avalanche evaluation and prediction was transferred to the Department of Northern Affairs and National Resources. The experience gained in combining the testing method with the analytic method has been passed on to this Department.

Defence Plan

Study of avalanche defence for the Rogers Pass route indicated that the cost of a defence that would guarantee a continuously open highway would be unreasonably high. It was realized also that the required structures for such a defence could not be built before the scheduled completion date of the highway. On the other hand it was recognized that a passive defence only would not avoid frequent and long closures, which could not be accepted for the Trans-Canada Highway. Based on these considerations a plan with three stages of defence construction, combining active defence with passive defence by highway closures, was chosen. The length of time that the highway would probably be closed each winter would be decreased with the completion of each stage.

The first stage of defence will be in operation when the highway is opened, and the other stages can be introduced later when more experience

TABLE II

Comparison of the Different Defences Based on 1960-1961 Prices

	Estimated Costs		*Closure of Highway in an Average Winter*		
	Estimated Initial Cost	*Annual Cost*	*Time*	*Total Days*	*Maximum Days*
Closures only, no active defence	\$ 20,000	\$40,000	25	75	10
First Stage: combined active and passive defence	5,300,000	52,000	7	12	6
Second Stage: combined active and passive defence	2,900,000	50,000	4	5	4
Third Stage: active defence only	1,400,000	70,000	None	—	—

with highway operation and avalanches is available and when shorter closure times are demanded. Studies on the defence required for the three stages were made and costs estimated in relation to prices for 1960-1961. The different stages are described below and their estimated effectiveness shown in Table II. Initial costs for the different stages are those for defence structures and for establishing an avalanche warning service. The annual cost is the estimated amount of money to be spent each year for control of avalanches by explosives and for the avalanche warning service, but does not include any cost for snow removal.

The First Stage of Defence

The following defence plan was chosen for the first stage of defence:

> Defence structures will be built that will give full protection at sites:
> — where the avalanche survey has indicated that dangerous dry snow direct action avalanches usually occur after snowfalls yielding less than 16 in. new snow when accompanied by wind, or less than 22 in. new snow without wind;
> — where spring thaw avalanches were observed to have reached the highway location regularly every year; and
> — where dangerous dry snow delayed action avalanches usually occurred at least once every year.

This means that defence structures are to be built at sites where avalanches would have affected the highway once or more than once each year during the period from 1953 to 1960. The plan required the construction of eight snowsheds, with a total length of 4,825 ft., a total of 80 earth mounds constructed at two sites, and catching dams at two sites with a total length of 800 ft. Associated with the snowsheds are diverting dams between 100 and 600 ft. long that confine the avalanches.

In addition to these structures it was decided to build a total of 240 earth mounds at seven sites, a total of 700 ft. of diverting dams at two sites and a total of 1,400 ft. of catching dams at three sites where avalanches were observed less frequently, but where the local conditions make inexpensive structures feasible. These secondary defences do not offer complete protection to the highway, but will probably retain smaller avalanches and reduce the size of larger ones.

Artillery fire is to be used against dry snow delayed action avalanches at sites that are unprotected or insufficiently protected by structures.

The highway is to be closed when dry snow direct action, wet snow direct action, or spring thaw avalanches are likely to occur at unprotected sites. This means that the highway would normally be closed until about 12 hours after snowfalls exceeding 16 in. when accompanied by wind or 22 in. without wind. Furthermore, it might be closed when a snowstorm is followed by warm weather or during days when larger spring thaw avalanches are likely to occur.

An avalanche hazard evaluation and prediction service is to be established that will determine when and where avalanches have to be controlled by artillery or the highway closed.

The Second Stage of Defence

The defence measures of the first stage are to be supplemented by structures to provide full protection at sites where wet snow direct action avalanches and spring thaw avalanches reach the highway more frequently than once in 10 years. Additional snowsheds, retaining barriers in rupture zones close to the highway, earth mounds and diverting dams will be built.

The Third Stage of Defence

This stage would guarantee an open highway for the whole winter, except for short intervals when explosives would be used to control direct action avalanches and dry snow delayed action avalanches at sites where no defence structures were built in the first and second stage. Additional defence structures would have to be built at sites where the terrain forbids artillery fire or where artillery fire would be uneconomical, as well as at sites where spring thaw avalanches may reach the highway.

Although defence structures for all stages will be designed for situations which may occur once in 10 years, conditions may be encountered once in 15 to 20 years that produce very large avalanches that follow unusual paths. An avalanche evaluation and prediction service will be necessary to determine the time and location for artillery fire and also to order closure of the highway for the extremely bad situations which may overcome the defence system.

Concluding Remarks

Avalanche observations and subsequent development of the defence system for the Trans-Canada Highway in the Rogers Pass area is the first project of this kind to be undertaken in Canada. It is to the credit of the engineers of the Department of Public Works that an avalanche survey was initiated with the first highway location studies in 1953. Because of their foresight, observations from seven winters were available upon which recommendations could be based for a defence plan and the specifications for the first stage of defence by the time detailed engineering planning was begun. The defence plan chosen was one that could be completed in successive stages, each stage giving greater protection to the highway. Structures near the highway, explosives and an avalanche evaluation and prediction service form its basis. Structures constructed for the first stage of defence will protect the highway at those sites where major avalanches will affect the highway once or more than once each year. The plan lays down principles to be followed in determining successive stages of defence, but details of this defence require further observations of the avalanches and their effect on the highway when it is in operation.

Acknowledgments

The work described in this paper was a joint project of the Division of Building Research of the National Research Council and the Development Engineering Branch of the Department of Public Works (Canada) under G. B. Williams, then Chief Engineer of the Branch and now Assistant Deputy Minister. The author was seconded for full-time duty with the Department from his normal service in the Snow and Ice Section of the Division. He wishes to acknowledge the assistance of the staff members of the Department of Public Works who assisted in making the field observations required for the avalanche defence program. The paper is a joint contribution from the Department of Public Works and the Division of Building Research and is presented with the approval of the Deputy Minister of the Department and the Director of the Division.

References

1. Hague, J. P. Selection of the Trans-Canada Highway Route through the Selkirk Mountains. The Engineering Journal, Vol. 41, June 1958, p. 57-60.
2. Chapman, J. D. and D. B. Turner. British Columbia Atlas of Resources. B. C. Natural Resources Conference, 1956.
3. de Quervain, M. R. Avalanche Classification. International Union of Geodesy and Geophysics, General Assembly of Toronto 1957, Vol. 4, Snow and Ice Commission, Gentbrugge 1958, p. 387-392.
4. Bucher, E. and others. Lawinen, die Gefahr für den Skifahrer. Geotechnische Kommission der Schweizerischen Naturforschenden Gesellschaft, 1940. Aschmann and Scheller, Zürich (out of print).
5. Forest Service, U.S. Department of Agriculture, Snow Avalanches. Agriculture Handbook No. 194, 1961.

THE BEECHWOOD FISH HOIST

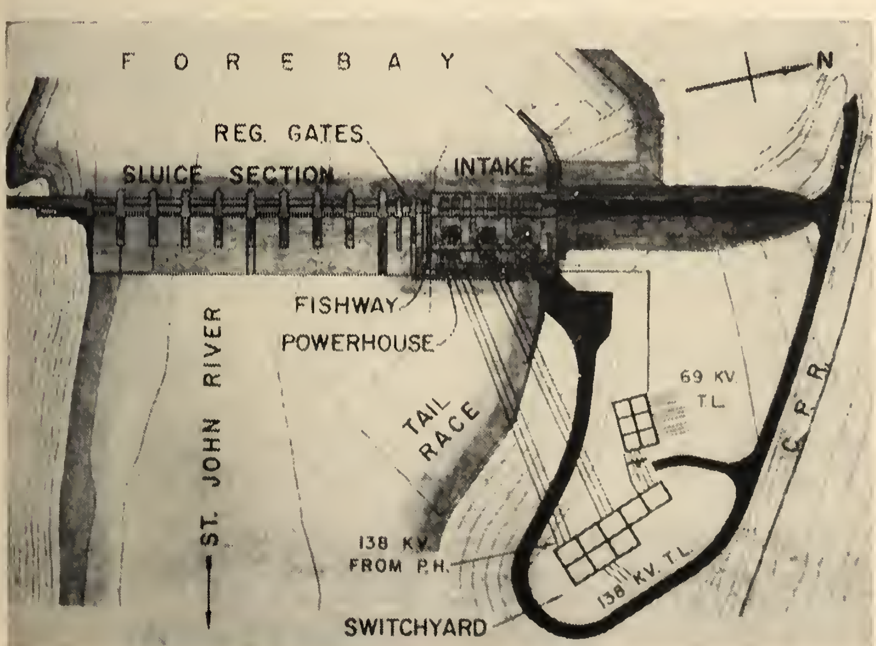
J. D. Denovan, M.E.I.C.,
Supervising Engineer, General Engineering Department.
The Shawinigan Engineering Company Limited

When designing the Beechwood hydro electric power station on the St. John River in New Brunswick, it was necessary to provide facilities for the transfer of Atlantic salmon to the forebay of the development from below the dam. An elevator fish hoist was selected to do this.

Presented at the 75th E.I.C. Annual General Meeting, Vancouver, May 1961.

ATLANTIC SALMON, "Salmo Salar", spawn in rivers occurring in restricted latitudes of Western Europe and North America. The original distribution in North America extended from southern New England to mid-Labrador. While increasing population and industrialization have been progressively pushing the southern extremity of distribution northward, salmon still occur in fluctuating numbers in some 300 streams and rivers of Canada's Atlantic provinces. It is estimated that 75% of the remaining salmon run to about six principal river systems of New Brunswick and Newfoundland.

Fig. 1.—General Arrangement of Structures



Records of salmon catches by commercial fishermen in various areas of the Atlantic provinces, excluding Newfoundland, indicate several peak years with production exceeding 3.5 million lb. In Newfoundland, commercial landings as indicated by export figures, fluctuate from 3 million lb. to over 6 million lb. Since 1930, the most recent peak year when over 13 million lb. of salmon were landed by commercial fishermen on the whole Atlantic coast, there has been a gradual decline in salmon catches by commercial nets. This has been mainly responsible for the recent widespread concern over the Atlantic Salmon stocks, notwithstanding the keen

awareness which exists for the value of the Atlantic Salmon as a game fish.

Among the rivers of New Brunswick utilized by the Atlantic Salmon for spawning is the Saint John River and its tributaries. Accordingly, when designing the Beechwood hydro-electric power station located on the St. John River, it was imperative that the engineers, in close association with the Department of Fisheries, incorporate fish handling facilities to pass salmon over the dam with a minimum of interference to their anadromous habits.

It is intended that this paper describe the fish handling facilities, and in particular the fish hoist, which were provided at the Beechwood Development of The New Brunswick Electric Power Commission and relate some of the operational experience gathered since these facilities were placed in service.

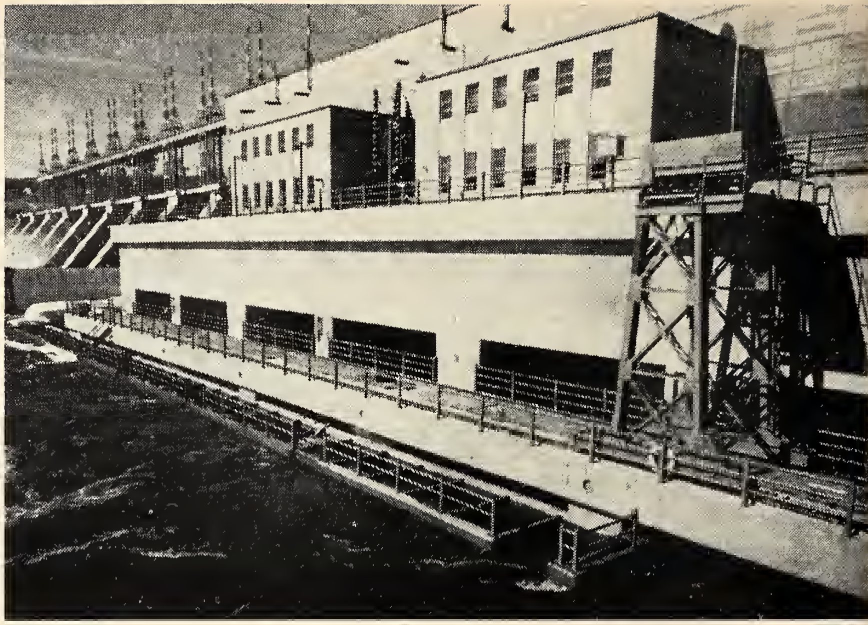
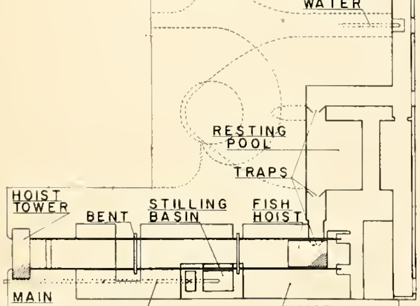


Fig. 3.—View of Fish Collecting Gallery above Draft Tube Exits

General Conditions Affecting Selection of Facilities

It is speculated that salmon probably enter the Saint John River every month of the year, with the greatest concentration appearing from May to August. Spring fish are predominantly two sea-year fish of 10-15 lb weight. These are followed by a summer run of smaller, one sea-year fish or grilse, and subsequently by a fall run of salmon larger in size than the spring fish. A run of immature females, weighing approximately 9 lb., enters the lower river between November and January but is reported to hold

Fig. 2.—General Plan of Fishway Facilities



in the lower reaches, proceeding upriver early the following spring. The spawning migration, as a rule, is not rapid. For example, the main spring spawning runs may take up to a month to traverse the 20 miles of fresh water influence outside the Saint John harbour before entering the river beyond the Reversing Falls. Upstream of the Falls, the pattern is variable. Early spring salmon may migrate rapidly to upriver sections and tributaries. However, as the water becomes warmer and river levels recede, migration is more sporadic and the salmon sometimes hold for months in pools near the tidehead, cool river holding pools or below rapids, falls and dams. Fall fish again move rapidly into the tributary spawning streams. Based on these migratory characteristics, it was established that the Beechwood facilities must be designed to pass salmon upstream over the dam during the period May to November each year.

A fairly conventional fish ladder had been in use for several years at the Tobique generating station of The New Brunswick Electric Power Commission prior to the construction of Beechwood Development. Since the ladder operating experience at this plant, located on a tributary of the Saint John River upstream from Beechwood, was deemed satisfactory, it was first proposed to construct a similar reinforced concrete structure at Beechwood Development. This structure would incorporate a fish collecting gallery and a ladder of alternating rises and rest pools conforming to a 1 in 12 slope. As the plant discharge would be so many times greater than the discharge from the collecting gallery, it followed that the gallery entrances should be located as close as possible to the larger flows so as to attract fish to the smaller flows from the gallery. Accordingly, the fish collecting gallery would be located vertically above the draft tubes of the generating station. The importance of so locating the gallery had been substantiated by operating experience at the Tobique generating station. While this criteria could be easily met at Beechwood, the construction of a reinforced concrete ladder in the space available and on the material along the east river bank, and the necessary control of settlement so as to maintain the required slopes would be difficult and expensive. Therefore, alternative facilities were investigated and a scheme incorporating a fish collecting gallery with an inclined fish elevator was selected. This scheme provided fish collecting gallery facilities identical to those used with the considered ladder arrangement. Therefore it could be expected that these facilities would attract and pass as many fish as would the original ladder scheme. It offered the advantage that the fish would be transported over the dam thus avoiding the physical strain and exhaustion associated with the ladder swim. Settlement and construction difficulties to be encountered by a ladder scheme would be avoided and the resulting economies were estimated to be substantial. At the same time, it was realized that the fish hoist scheme inherently involved the risk of possible mechanical breakdown and introduced a human element provid-

ng additional hazards to the success-ul passage of fish not usually associ-ated with conventional fish ladders.

General Arrangements of Structures

The dam structures extend from the west to east bank of the Saint John River and consist of a concrete bulk-head section at the west abutment connecting with a sluice and regulat-ing section, and an earth embankment at the east abutment connecting with the intake-powerhouse section. The fishway is located between the intake-powerhouse and regulating sections. (Fig. 1)

General Scheme of Facilities

A fish collecting gallery is located along the downstream face of the powerhouse vertically above the draft tube exits. Fish attracted by the plant discharge approach the power-house and, attracted by flow from the gallery, enter via openings located in the downstream gallery wall. Tra-velling westward along the gallery, fish enter a resting pool over the draft tube at Unit 1. From the resting pool, the fish swim along a short tunnel entrance to the skip of the fish hoist. Once in the skip, the fish are elevated to the top of the dam and spilled into the forebay to continue their migra-tion upstream. (Fig. 2.)

Fish Gallery

The fish collecting gallery is lo-cated along the downstream face of the powerhouse vertically above the draft tube exits to take full advantage of the plant flows attracting the mi-grating salmon. (See Fig. 3.)

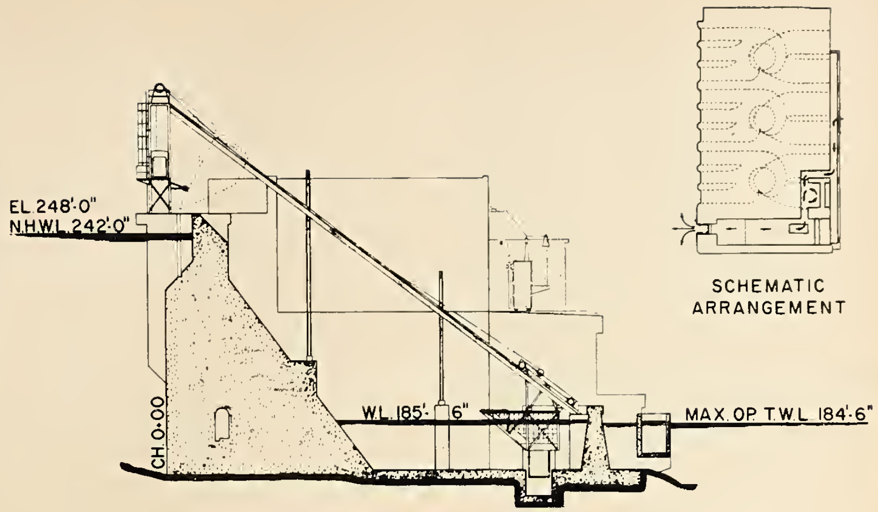


Fig. 4.—Arrangement of Fish Hoist

Design criteria established that the floor of the gallery should be level and at least 4 ft. lower than low tail-water during the period June 1 to October 31, the duration of the fish run in this section of the St. John River. Similarly, the walls of the gal-lery should be high enough so that at least 2 ft. of freeboard would exist at high tailwater during the same period. Openings were to be provided in the downstream wall of the gallery and were to extend from the low tail-water level to the top of the gallery wall. These openings were to be 6 ft. wide and located approximately 30 ft. on centres. The openings were to be equipped with stop logs or telescopic gates to provide an overflow type of discharge during all tailwater stages during the period June 1 to October 31.

Fig. 5.—View of Fish Skip and Suspension Frame

Accordingly, the Beechwood fish gallery, constructed of reinforced con-crete and structural steel, measures 8 ft. wide with floor elevation 175 ft. and top of walls at elevation 187 ft. These levels correspond to an operat-ing tailwater range of elevation 179 ft. to elevation 184 ft. 6 in. Five open-ings, 6 ft. wide with sill elevation 179 ft., are located at and midway be-tween the centre line of each unit (i.e., 35 ft. centres). Each opening was originally equipped with 4 in. x 12 in. nominal Douglas fir stop logs.

At the centre line of the first unit, the gallery turns upstream and con-nects to a resting pool located be-tween the draft-tube roof and draft-tube deck upstream from the gallery. Since this section of gallery is directly over the draft tube gate slot, a remov-able water-tight structural steel closure piece fitted to the draft tube gate well forms a segment of the gal-lery floor and walls. The resting pool measures approximately 23 x 28 ft. An adjustable-vane fish trap is located at the entrance to the resting pool to discourage the fish from re-entering the gallery once they enter the resting area.

A tunnel connects the resting pool to the fish-hoist well. A second adjust-able-vane fish trap is located in the tunnel to discourage the re-entry of the fish to the resting pool once they advance along the tunnel towards the skip. This trap, identical to the trap between the gallery and resting pool, consists of forty vanes $3\frac{1}{2}$ in. wide standing vertically to cover the full range of operating water levels. The vanes are arranged in V-formation with the apex directed towards the water flow. Twenty vanes are ar-ranged on each side of "V" and the sides are inclined 45° towards the

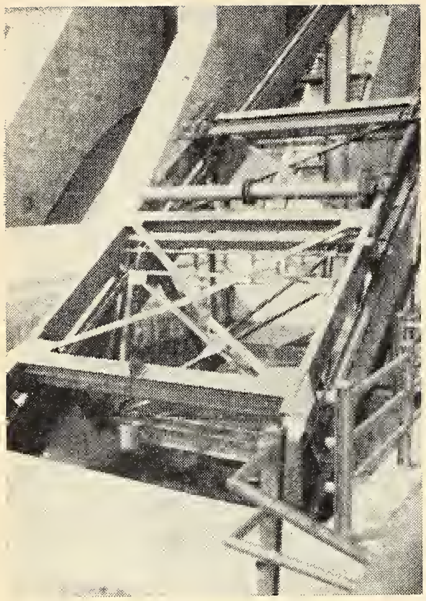
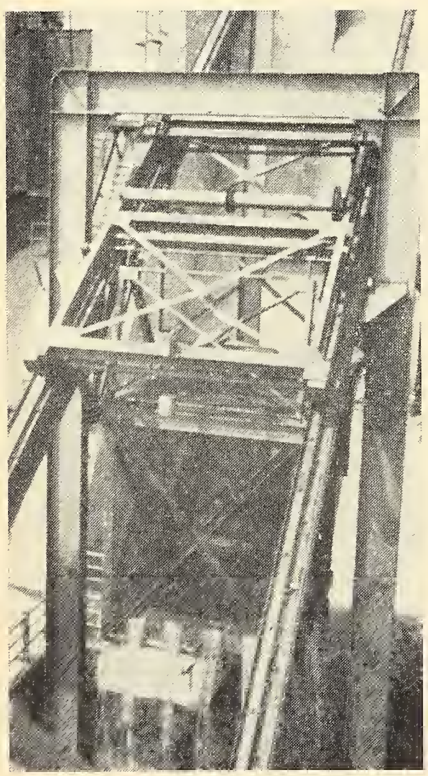


Fig. 6.—View of Trolley in Lowered Position. Skip Gate Hoist Drum in Centre Foreground; Hoist Bar, Compressed Bumper Springs Upper Right.

direction of flow. The vanes may be adjusted simultaneously by a control wheel and connecting linkage from a fully closed position to a 3 in. maximum opening between vanes. An 8 in. clear opening between vanes is provided at the apex of the "V".

A 12 ft. high x 6 ft. 5 in. wide "closure" gate, consisting of a structural steel frame covered with 1 in. x 3/16 in., galvanized steel wire mesh, is located at the exit of the tunnel entrance to the skip. This gate is raised and lowered by the correlated operation of the fish hoist gate and drops into a recess in the floor of the fish hoist well when in the open position. The gate travels 9 ft. vertically from the fully open to fully closed position, weighs 640 lb. and is suitably counterweighted to provide smooth operation.

Fig. 7.—Fish Skip Being Raised from Hoist Well. Locking Frame and Lever on Suspension Frame—Centre Foreground.



The Fish Hoist

The fishway section of the dam structures consists of a mass concrete gravity section bulkhead extending between the intake and regulating sections, a concrete retaining wall extending between the powerhouse and regulating section training wall, a fish hoist well formed by the two aforementioned components, a feedwater stilling basin located within the hoist well and a fish hoist. (Figs. 2 and 4)

The fish hoist may be generally described as an inclined elevator consisting of a cage-like skip suspended from a trolley which travels along a pair of inclined rails extending from the powerhouse and tailrace level to above the crest of the dam and forebay level.

The skip, fabricated from structural steel members, measures 10 ft. wide x 10 ft. long bottom plan, 10 ft. wide x 24 ft. long top plan and is 12 ft. 6 in. high. The sides, downstream face and a portion of the top are covered with 1 in. x 3/16 in. galvanized steel mesh. (Fig. 5.) The spout or spilling side and the bottom are steel-lined and this lining is extended up all sides to a height of 1 ft. 6 in. from the bottom, although spilling slots have been cut at 1 ft. from the bottom. The spout is fully lined. This steel lining provides a minimum depth of 1 ft. of water for floating the fish during the hoisting procedure and also retains sufficient water when the skip is tipped in the spilling position so that the fish are "spill-floated" into the forebay. The V-shaped spilling end also assists in meeting this requirement in the latter instance. Ensuring a suitable depth of water to float the fish consistent with keeping it to a minimum to avoid excessive hoist capacity is of course the objective in this regard.

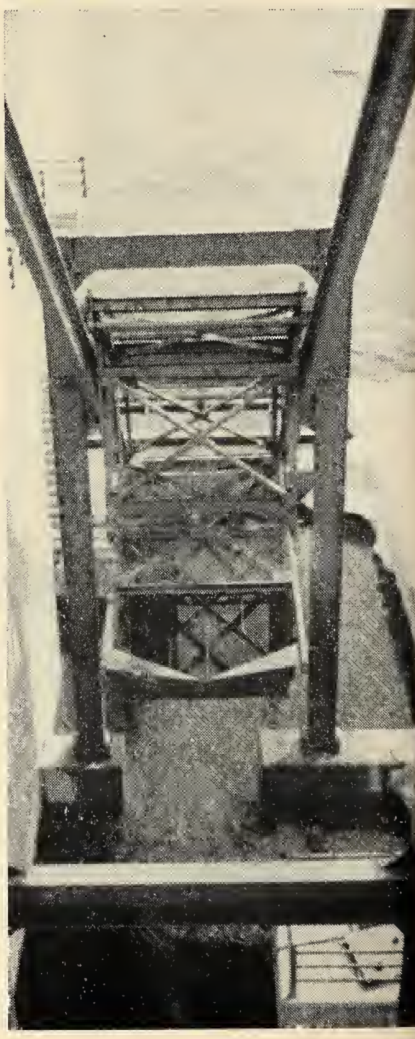
The skip is fitted with a closure gate, 12 ft. high x 6 ft. 5 in. wide, located at the side of the skip in line with the tunnel entrance gate when the skip is in the filling position. This gate consists of a structural steel frame covered with 1 in. x 3/16 in. galvanized steel mesh. In line with the gate and within the skip, a mesh covered trap is provided to discourage the fish from re-entering the tunnel once they have entered the skip. The two sides of the trap are inclined at 45° towards the direction of flow and an eight-inch opening is provided at the apex of the "V".

The skip is suspended from the trolley by means of structural steel framing, designed to incorporate pivot points and guide bars which enable the skip to be tipped from the horizontal to approximately 54° in the spilling position. The skip is in the horizontal plane when being filled, hoisted and lowered.

The trolley consists of a structural steel frame mounted on four 15 in. double-flanged wheels (two per side) and incorporates operating mechanisms for tipping the skip and raising or lowering the closure gate.

The trolley runway consists of 45 lb. ASCE rails mounted on 15 in. @ 50 lb. channels overlying 24 in. I's @ 79.9 lb. The twin rails are 12 ft. 6 in. on centres and the runways span between the hoist tower at the crest of the dam, two steel bents 24

Fig. 8.—Fish Skip in Transit Upstream —looking downstream



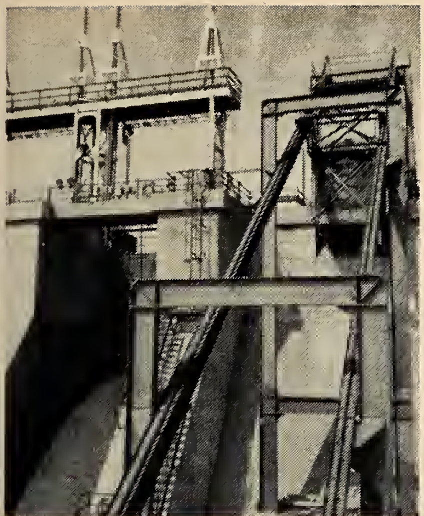


Fig. 9.—Fish Skip at Top Level Just Prior to Spilling Procedure

in. WF @ 110 lb. located approximately at the third points, and the concrete retaining wall downstream of the fish hoist well. The runways are inclined 36° 4′ 2″ to the horizontal plane. Operating levers, mounted on the runway, and limit switches are provided to initiate and control the various operating features of the hoist and skip.

Structural steel hoist towers are located at the crest of the dam and serve to support the upper runway span and house the hoisting machinery. (Fig. 12) Also fitted to the tower is a tipping roller, which engages the skip during the tipping operation for spilling. A 50 hp. 1090 r.p.m., 550 V, three phase, 60 cycles electric motor, acting through suitable gear trains, drives the twin 24 in. diameter drums of the hoist. Two ⅞ in. diameter x 6/19 improved plow steel wire ropes from the drums thread through 24 in. diameter sheaves at the head of the tower and connect to a hoist bar fitted to the trolley frame. The hoisting mechanism installed is manual-controlled, but provisions have been made for later installation of automatically-timed operation.

Operation of Fish Hoist

In the lowered position, the trolley rests against stop blocks or bumpers at the base of the runways. The skip gate, engaged via levers to the tunnel entrance gate, is in the lowered open position and fish may enter the skip from the tunnel entrance.

As hoisting commences, the hoist ropes pull the hoisting bar on the trolley frame upwards towards hoisting bumpers ultimately compressing bumper springs, whose significance will be noted later. (Fig. 6) As the hoisting bar moves upwards, flexible-wire ropes connecting the bar to the gate hoist drum tighten and cause the drum to rotate, raising the skip gate. As the weight of the skip gate is lifted, the entrance tunnel gate raises to the closed position under action of the counter-weight. A latching device engages the skip gate in the raised position to ensure that it does not open during the hoisting or spilling operation. When the hoist bar comes in contact with the hoisting bumpers and has fully compressed the bumper springs, the trolley and suspended skip commence to travel up the inclined runway at a hoisting speed of 50 f.p.m. When the skip approaches the top of its travel, the upper leading edge of the skip engages a tipping roller fitted to the hoist tower. Just prior to this instance, a lever releases a locking frame which keeps the skip in the horizontal plane during hoisting. (Fig. 7) As the trolley continues to move upwards with the locking frame released and the leading edge engaged by the tipping roller, the skip pivots forward about the suspension frame spilling its contents into the forebay. (Figs. 8 to 12 inclusive.)

When lowering, the skip returns to the horizontal position, the locking frame is re-engaged and the skip travels down the runway to the lowered position. As it reaches the lowered position, the gate latching lever is released and the skip gate engages the entrance tunnel gate. As the weight of the skip is taken by the

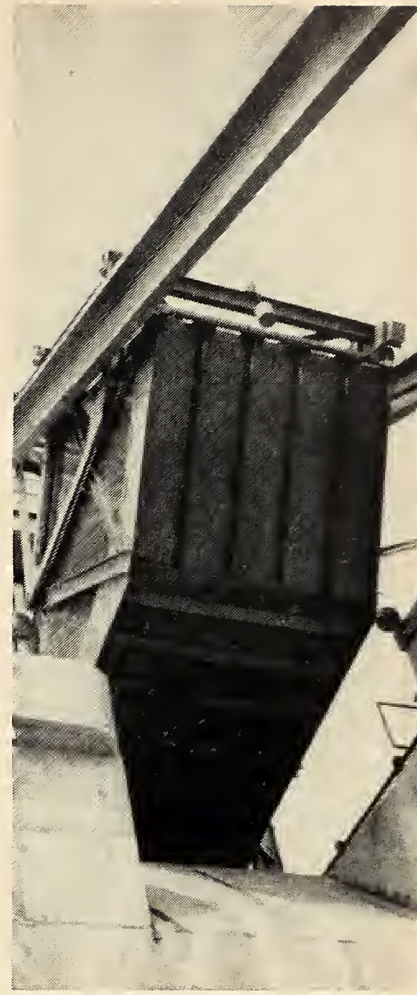


Fig. 10.—Fish Skip in Spilling Position

Fig. 11.—Side View of Fish Skip in Spilling Position. Tipping Roller Engaging Spilling Edge of Skip—Left Foreground

runway bumpers, the compressed springs on the trolley bumpers plus the weight of the gate cause the hoisting bar to continue its travel down the incline, thus unwinding the gate hoist drum. The combined weight of the skip gate and engaged entrance tunnel gate overcome the counterweight on the tunnel gate, and both gates lower to the open position. Limit switches are suitably located to control the operation of the hoist machinery.

Auxiliary Equipment

Design criteria established that a flow of 12 c.f.s. per gallery opening would be required and that seldom more than one and at the most two openings would be used simultaneously. Accordingly, a 12 in. water supply pipe is installed from the forebay to the fish hoist well which supplies a maximum of 17 c.f.s. at the minimum head condition. The main water supply pipe discharges through a diffuser into a stilling basin located in the fish hoist well. Water flows to the fish hoist well over a weir in the basin wall and a throttle valve is conveniently located in the vicinity of the stilling basin to control the discharge. A 10-in. make-up water line is installed from the forebay to discharge into a diffuser pit located between the second and third openings of the fish gallery.

Drains are provided throughout the facilities to empty the hoist well, stilling basin, resting pool and gallery.

Air supply connections to the water supply lines are provided to clear blocked intake screens. An air blast line is also provided at the entrance tunnel gate well to clear debris which may gather in this recess.

Walkways and ladders are installed to make all facilities readily accessible.

Operating Experience Since Placed in Service

Only time will determine whether the Beechwood fish passing facilities adequately serve their intended purpose. Results to date are encouraging. Recorded counts of salmon raised by the Beechwood fish hoist since placed in service are as follows:

Year		*Total Number of Salmon Passed by Hoist*
1957 (Fishway placed in service by August.)		1,127
1958		4,565
1959		2,588
1960		2,688
Maximum number of salmon raised for:		
One day	—August 31, 1958	279 salmon*
	July 10, 1960	241 salmon
One week	—Aug. 31 to Sept. 6, 1958	804 salmon*
	July 10 to July 16, 1960	616 salmon
Any 7-day period	—Aug. 30 to Sept. 5, 1958	1,007 salmon*
	July 5 to July 11, 1960	886 salmon
One month	—July, 1960	1,824 salmon

The unusually large counts of salmon at Beechwood during the last part of August and September, 1958, (denoted by asterisks) may be explained by the extremely high water conditions during the previous 10-day period. During this time, the fishway collection gallery and skip hoist were completely submerged. Very strong currents and eddies caused by high river flows prevailed in the vicinity of the gallery and salmon were unable to find the relatively small flow from the submerged gallery entrances. Undoubtedly, the rise in water levels and flows encouraged the salmon to move up to the tailrace area from holding pools below and, being unable to discover the gallery entrances, the salmon congregated in large numbers immediately below the dam. As the tailrace level dropped, the attractive flow from the gallery became evident to the salmon in the area and the large number recorded entered the fishway. After about a week, the run dropped off near the expected normal. Accordingly, the alternate 1960 figures are probably more representative.

Although no counts of salmon passing the Beechwood site are available for years prior to 1957, the numbers were estimated to be approximately twice the number ascending the Tobique fish ladder. Tobique salmon counts are as follows:

1953	4,656 salmon
1954	4,984 salmon
1955	3,776 salmon
1956	3,724 salmon
1957	569 salmon
1958	2,635 salmon
1959	949 salmon (plus 755 transported from Beechwood by truck)
1960	1,120 salmon (plus 1,089 transported from Beechwood by truck)

It is evident that the estimated salmon run at Beechwood has not been realized. Department of Fish-

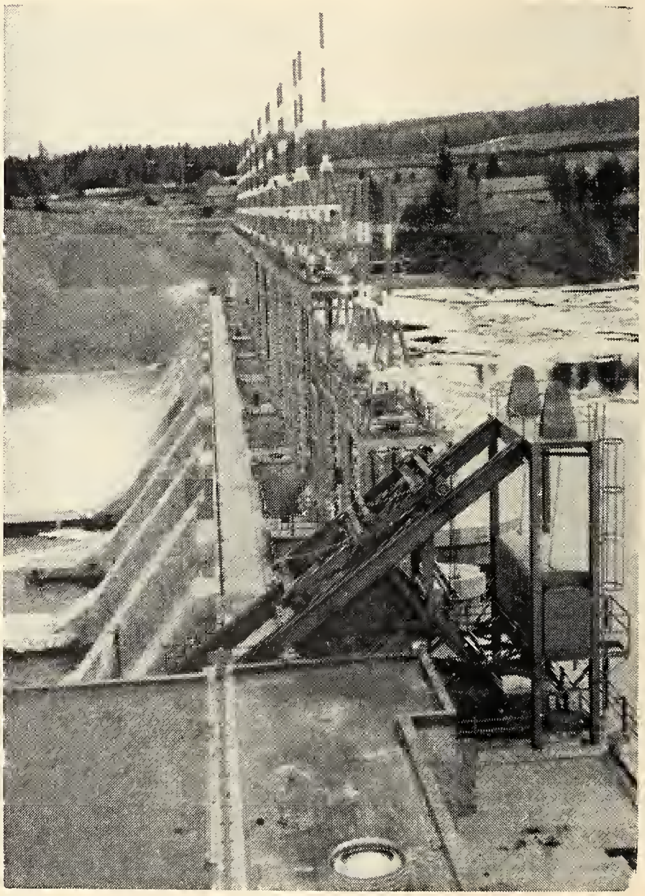


Fig. 12. Fish Skip in Spilling Position—Hoist Tower, Housing and Sheaves Right Foreground.

eries representatives believe that the runs are below normal as a result of mortalities to juvenile fish received from the DDT forest spraying operations on the Tobique and adjacent watersheds in the years 1953-55-57 and 58. The size of run is expected to be minimal through 1961 but is forecasted to increase thereafter.

While the above data has referred exclusively to salmon, it is interesting to note that some 21 species of fish utilize the fishway to varying degrees throughout each operating season.

It has been one of the principal objectives of the Department of Fisheries to establish an operating regimen for the fish facilities at Beechwood with a view to placing the fishway on automatic operation with fish counts automatically recorded. Operating experience to date indicates that salmon enter the collection gallery and skip hoist satisfactorily at river flows between 10,000 c.f.s. and 20,000 c.f.s. and tailrace levels near 184 ft., provided that the water flow to the fishway is maintained above 24 c.f.s. for one entrance and the velocity is 4 ft. or more per second. An auxiliary intake water supply line, connected to the main water supply for operating the fishway at low forebay levels during construction prior to raising the forebay, has served to meet this increased flow requirement above original estimates. However, an additional feedwater source is being considered in order to enable more gallery entrances to be operated simultaneously.

While entrance shape to the gallery does not appear to be critical, location does, being at its best near or over an operating turbine. Various types of entrances to the collection gallery have been devised and experimented with in actual service. These include a simple weir type of varying depths and widths, underwater orifices of varying types and shapes and a full depth slot. Continued experimentation to determine which size, shape and location works most efficiently for various species under varying conditions of flows and levels is planned for the future. To date, an underwater inverted triangular-shaped orifice, approximately 6 ft. wide by 18 in. deep, appears to be most satisfactory for salmon. This orifice operates quite efficiently under a fairly extensive tailrace level range without adjustment. However, the aim is to find an entrance most generally suited to all important species, and which can be fished with as little adjustment and attention as possible.

The salmon fallback is low but nevertheless significant, about 8%. It is suspected that most of this is due to fatigue of the fish, resulting from handling in the fish hoist due to investigational procedures rather than features of the facilities themselves.

Modifications to Fish Hoist and Facilities as Result of Operating Experience

Because of the necessity for frequent changing of the gallery entrances and experimentation with types and shapes of orifices, lighter and more easily handled stop logs of 2 in. x 3 in. framing faced with ¾ in. plywood were installed to replace the original Douglas fir logs.

A new set of stop logs was installed between the tunnel entrance to the skip and resting pool to enable the hoist well to be drained independently of the remainder of the fishway facilities.

A permanent sliding metal-screened top and lock was installed at the open mouth of the skip hoist to prevent salmon or other species from swimming or jumping out of the skip into the fish hoist well when operating during high tailwater levels. Considerable difficulty had been experienced in this regard prior to the modification.

A small open shelf originally existed above the fish trap in the skip which tended to strand fish when water levels in the hoist well dropped suddenly. This shelf was screened off to the top level of the skip.

The skip hoist floor was divided by 1 ft. high steel walls into four full length sections to facilitate dipping of the fish for tagging or examination and to assist counting of the catch.

Contemplated Modifications to the Fishway

In 1958, a large number of salmon were found to have sounded below the level of the collection gallery and surfaced in the blind pools above the draft tube roof. Although escape was possible by the reverse route, the fish continued to swim near the surface and did not find their way out for some time. Auxiliary entrances in the upstream wall of the gallery might have avoided the delay of these fish. Since this situation has not recurred to any great extent, the addition of auxiliary entrances is being held in abeyance for the present. However, implementation of the scheme will be considered if any concentration of fish appear in these areas in the future.

As was previously mentioned, an additional water supply to the facilities is being considered to permit the use of a greater number of gallery entrances.

The raising of the gallery walls (approximately 3 ft.) is being examined with a view to operating over a wider range of tailwater levels.

Automatic operation of the hoist and counting methods are being considered. Provision for these facilities was made in the original design.

Conclusion

It will be noted that these facilities provide for passage of fish upstream over the dam only. To return to the sea, the fish must pass the dam via spillway facilities or through the turbines. Discussion in this regard has been omitted since this specialized subject is thoroughly considered in another paper presented at this meeting.

Facilities of this nature must necessarily be adapted to operating experience gained after installation. Several years of operation are required before the true measure of adequacy can be determined. To date, the operation of the Beechwood fish hoist is considered encouraging.

It is hoped that the foregoing will be of interest and use to engineers faced with the similar task of providing facilities to pass fish over power dams or other structures constructed in rivers frequented by anadromous species of fish. While development of our natural hydraulic resources is essential, the engineer must pay careful attention to and provide for the preservation of the natural wildlife which exists in the rivers and streams on which he builds.

Acknowledgements

The Beechwood Development is owned and operated by The New Brunswick Electric Power Commission. The general contractor was Foundation Company of Canada Limited and the project was designed by The Shawinigan Engineering Company Limited. The fish hoist was designed in close association with the Department of Fisheries and was fabricated by Dominion Bridge Company Limited. The author gratefully acknowledges the kind assistance received in the preparation of this paper from Mr. R. E. Tweeddale of The New Brunswick Electric Power Commission, Dr. A. L. Pritchard, Dr. R. R. Loggie, Mr. G. A. C. Wilson and Mr. K. E. H. Smith of the Department of Fisheries. EIC

"THERMAL WEDGE EFFECT IN HYDRODYNAMIC LUBRICATION"

John Young,

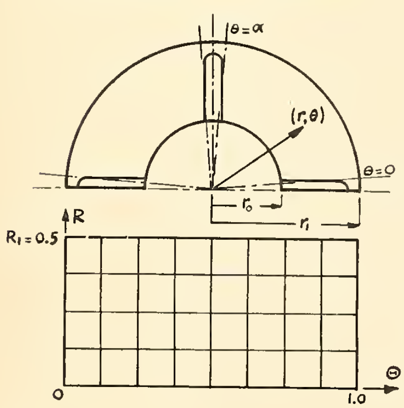
Assistant Professor, Department of Mechanical Engineering
The University of British Columbia, Vancouver

The general Reynolds equation and the energy equation which govern the thermal wedge mechanism are solved in this paper in three ways, showing the effect of certain initial assumptions in the analysis.

Presented at the 75th E.I.C. Annual General Meeting, Vancouver, May 1961.

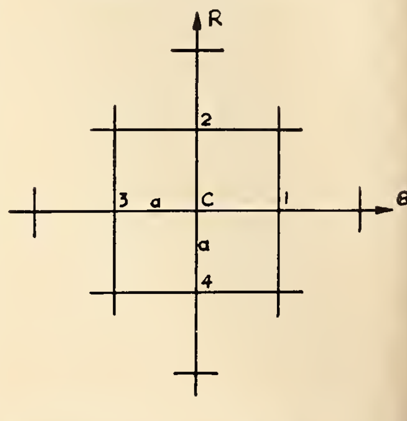
ON SEVERAL occasions, thrust bearings composed of flat parallel surfaces have shown indications of fluid film lubrication in contradiction to classical lubrication theory which requires a "taper wedge," or geometrical restriction in the direction of flow. High load-carrying capacities, in the order of 1,000 lb./in.^{2}, have been reported for parallel-surface bearings by Newbigin[1] and by Fogg[2]. An explanation of this phenomenon suggested by Fogg is that a "thermal wedge" is formed due to a temperature gradient around the bearing in the direction of motion, the restriction of flow being caused by an expanding volume of fluid passing between parallel plates.

Fig. 1. Sector Pad and Rectangular Transformation



This suggestion caused subsequent re-examination of the Reynolds equation and several solutions were produced in which the assumption of mass continuity through the bearing replaced the former assumption of volume continuity, thus taking account of the expansion of the lubricant. In spite of a convincing amount of theoretical work produced since Fogg's paper, there still remains some dubiety about the existence and effect of a "thermal wedge" in an actual bearing, because no positive correlation between theory and experiment has yet been made. The new solutions to the Reynolds equation could not be checked against experimental results because the amount of published data was small and incomplete due to the unreliable nature of the parallel-surface bearing, and

Fig. 2. Grid Notation



generally the solutions themselves were obtained by making simplifying assumptions—in particular, the common assumptions of constant viscosity, and of an infinitely wide bearing—which have little physical justification and which make comparisons difficult.

In this paper, the general Reynolds equation and the energy equation governing the thermal wedge behaviour (derived by Cope[3]) are solved in three ways, illustrating the effect of these assumptions. From these solutions, theoretical performance curves are obtained which can be applied directly to an actual bearing.

Theory

In the present notation, the well-known equations of Cope governing the thermal wedge behaviour between parallel surfaces are :

$$\frac{\partial}{\partial x}\left(\frac{\rho h^3}{12v}\frac{\partial p}{\partial x}\right) + \frac{\partial}{\partial y}\left(\frac{\rho h^3}{12v}\frac{\partial p}{\partial y}\right) = \frac{\partial}{\partial x}\left(\frac{\rho U h}{2}\right) \qquad (1)$$

$$\sigma\rho J\left[\left(\frac{Uh}{2} - \frac{h^3}{12v}\frac{\partial p}{\partial x}\right)\frac{\partial t}{\partial x} - \left(\frac{h^3}{12v}\frac{\partial p}{\partial y}\right)\frac{\partial t}{\partial y}\right] = \frac{h^3}{12v}\left[\left(\frac{\partial p}{\partial x}\right)^2 + \left(\frac{\partial p}{\partial y}\right)^2\right] + \frac{U^2 v}{h} \qquad (2)$$

Equation (1) is the general Reynolds equation including the effect of variations in density, and equation (2) is an energy equation. These equations were derived from the fundamental equations of flow—the equation of mass continuity; the momentum or Navier-Stokes equations, and a complete energy equation—by making simplifications only after careful consideration of the order of magnitude of the terms involved. Since these equations contain four unknown quantities, two further equations are required. It will be assumed that both density and viscosity are functions of temperature only and can be expressed thus :

$$\rho = \rho_0(1 - \lambda t) \qquad (3)$$

$$v = v_0 e^{-\beta t} \qquad (4)$$

For a complete solution, these four equations must be compatible, and should be solved simultaneously.

Methods of Solution

Solution for No Side Leakage: The simplest solution is obtained by assuming an infinitely wide bearing, in which there is no side leakage and variations in the axial direction can be neglected. This solution is similar to that of Osterle, Charnes and Saibel.[4]

The governing equations become

$$\frac{d}{dx}\left[\frac{\rho U h}{2} - \frac{h^3}{12v}\frac{dp}{dx}\right] = 0 \qquad (5)$$

and

$$\rho\sigma J\left[\frac{Uh}{2} - \frac{h^3}{12v}\frac{dp}{dx}\right]\frac{dt}{dx} = \frac{h^3}{12v}\left(\frac{dp}{dx}\right)^2 + \frac{U^2 v}{h} \qquad (6)$$

Equation (5) can be integrated to give the pressure equation as

$$\frac{dp}{dx} = \frac{6vU}{h^2}\left(1 - \frac{\rho_m}{\rho}\right) \qquad (7)$$

and substituting for dp/dx in equation (6) and simplifying

$$\frac{dt}{dx} = \frac{2vU}{h^2\sigma\rho_m J}\left[1 + 3\left(1 - \frac{\rho_m}{\rho}\right)^2\right] \qquad (8)$$

The subscript m refers to the point in the bearing where $dp/dx = 0$, i.e. at the point of maximum pressure. The density and viscosity equations (3) and (4) are now introduced to give after integration and simplification.

$$t = \frac{1}{\beta}\ln(Gx + 1) \qquad (9)$$

where

$$G = \frac{2Uv_0\beta}{h^2\sigma J\rho_m}$$

and

$$p = p_m - \frac{3}{2}\lambda\sigma J\rho_m(t - t_m)^2 \qquad (10)$$

The end conditions are

$$p = 0 \text{ at } x = 0, L$$

$$\text{and } t = 0, t_L$$

Thus

$$t_L = \frac{1}{\beta}\ln(GL + 1) \qquad (11)$$

$$t_m = \frac{t_L}{2}$$

and

$$p_m = \frac{3}{2}\lambda\sigma J\rho_m t_m^2$$

These equations for t and p are later evaluated for a particular set of operating conditions and compared to the values obtained by the following two solutions.

Solution by a Relaxation Method: A rigorous solution of the governing equations being impractical, the most accurate results are obtained by a numerical method. One such method is a relaxation process first applied to lubrication by Christopherson.[5]

Equations (1) and (2) are rewritten in polar coordinates, referring to a sector pad, Fig. 1, with boundaries

$$\theta = 0 \text{ and } \alpha \text{ and}$$

$$r = r_0 \text{ and } r_1$$

The Reynolds equation becomes

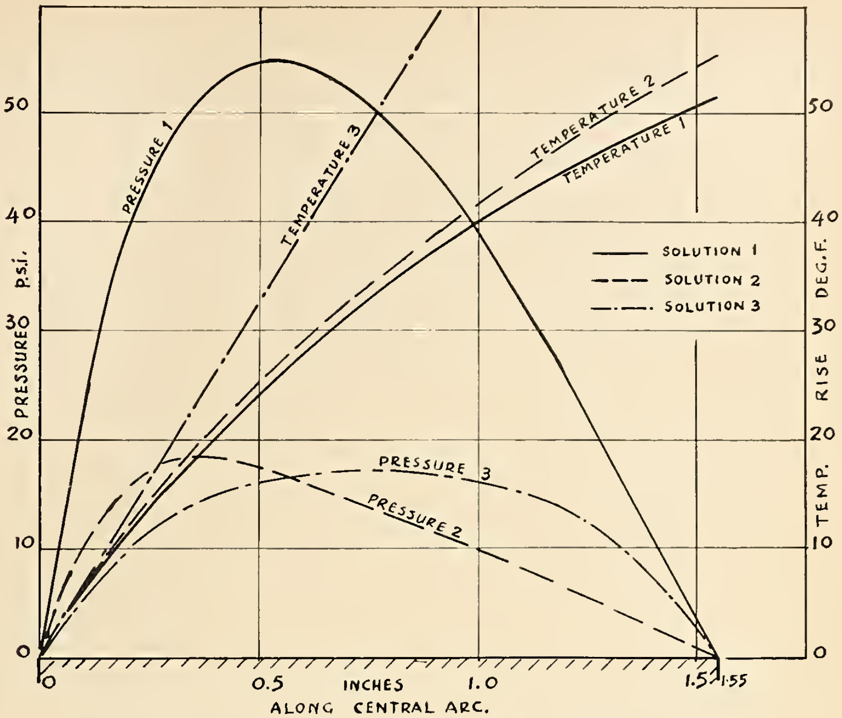


Fig. 3. Pressure and Temperature Curves along Central Arc (Calculated by 3 methods)

$$\frac{\partial}{\partial \theta}\left(\frac{h^3\rho}{v}\frac{\partial p}{\partial \theta}\right) + r\frac{\partial}{\partial r}\left(\frac{h^3\rho}{v} r \frac{\partial p}{\partial r}\right)$$
$$= 6\omega r^2 \frac{\partial}{\partial \theta}(\rho h) \qquad (12)$$

and the energy equation

$$J\rho\sigma \left\{\left(\frac{\omega h}{2} - \frac{1}{r^2}\frac{h^3}{12v}\frac{\partial p}{\partial \theta}\right)\frac{\partial t}{\partial \theta} - \frac{h^3}{12v}\frac{\partial p}{\partial r}\frac{\partial t}{\partial r}\right\}$$
$$= \frac{h^3}{12v}\left\{\left(\frac{\partial p}{\partial r}\right)^2 + \frac{1}{r^2}\left(\frac{\partial p}{\partial \theta}\right)\right\} + \frac{\omega^2 r^2 v}{h} \qquad (13)$$

The two equations are then reduced to a non-dimensional form and the sector pad transformed to a rectangular pad by the following substitutions:

Let $p = P\dfrac{6v_0\omega\alpha r_0^2}{h^2}$;

$\rho = D\rho_0$;

and $v = Mv_0$

and change the variables by putting

$$\theta = \Theta\alpha$$
$$r = r_0 e^{\alpha R}$$

The equations now become

$$\frac{\partial}{\partial \Theta}\left(\frac{D}{M}\frac{\partial P}{\partial \Theta}\right) + \frac{\partial}{\partial R}\left(\frac{D}{M}\frac{\partial P}{\partial R}\right) = e^{2\alpha R}\frac{\partial D}{\partial \Theta} \qquad (14)$$

and

$$\left(1 - \frac{e^{-2\alpha R}}{M}\frac{\partial P}{\partial \Theta}\right)\frac{\partial t}{\partial \Theta} - \left(\frac{e^{-2\alpha R}}{M}\frac{\partial P}{\partial R}\right)\frac{\partial t}{\partial R}$$
$$= \frac{1}{D}\left\{\frac{e^{-2\alpha R}}{M}\left[\left(\frac{\partial P}{\partial R}\right)^2 + \left(\frac{\partial P}{\partial \Theta}\right)^2\right] + \frac{M}{3}e^{2\alpha R}\right\}\frac{6v_0\omega\alpha r_0^2}{J\rho_0\sigma h^2} \qquad (15)$$

These equations relate to a rectangular pad, Fig. 1, with boundaries

$$\Theta = 0 \quad \text{and} \quad 1$$
$$R = 0 \quad \text{and} \quad \frac{1}{\alpha}\ln\frac{r_1}{r_0}$$

Pressure Equation.

Using the method of Christopherson, the pressure equation can be written in a finite difference form

$$\sum_{n=1}^{4}\left[\left(\frac{D}{M}\right)_n + \left(\frac{D}{M}\right)_c\right]P_n - P_c\sum_{1}^{4}\left[\left(\frac{D}{M}\right)_n + \left(\frac{D}{M}\right)_c\right] - 2a^2\frac{\partial D}{\partial \Theta}e^{2\alpha R} = 0 \qquad (16)$$

which gives the pressure parameter P_c at any point C on a grid of mesh size "a". The summation sign refers to four points equally spaced around C at the intersections of the grid, Fig. 2. One equation of this type is obtained for each intersection, except at the boundaries where the pressure is zero, giving a set of simultaneous equations which may be solved to obtain the complete pressure distribution. The relaxation process as described by Christopherson[5] and others is suitable for this type of problem.

Briefly, any value is assumed initially for the pressure distribution, and on substituting the assumed pressures in equation (16), in general the equation will not equal zero, but some value F, called the residual. The relaxation process involves altering the assumed pressure values at each point by ΔP until all the residuals are zero or reduced to a negligible quantity. The effect of a change ΔP on the residuals is

$$-\sum_{1}^{4}\left[\left(\frac{D}{M}\right)_n + \left(\frac{D}{M}\right)_c\right]\Delta P$$

at each point which is altered and

$$+\left[\left(\frac{D}{M}\right)_n + \left(\frac{D}{M}\right)_c\right]\Delta P$$

at each surrounding point n. These factors are called the influence coefficients, a_{cc} and a_{cn}.

Energy Equation

The energy equation (15) can be referred to the same grid and written in the form

$$\left(1 - \frac{e^{-2\alpha R}}{M_c}\frac{P_1 - P_3}{2a}\right)\left(\frac{t_1 - t_3}{2a}\right) - \left(\frac{e^{-2\alpha R}}{M_c}\frac{P_2 - P_4}{2a}\right)\left(\frac{t_2 - t_4}{2a}\right)$$
$$= \frac{1}{D_c}\left\{\frac{e^{-2\alpha R}}{M_c}\left[\left(\frac{P_1 - P_3}{2a}\right)^2 + \left(\frac{P_2 - P_4}{2a}\right)^2\right] + \frac{M_c}{3}e^{2\alpha R}\right\}\frac{6v_0\omega\alpha r_0^2}{J\rho_0\alpha h^2} \qquad (17)$$

This equation gives the temperature distribution for a known or assumed initial pressure distribution.

Starting at the inlet edge where $t = 0$ and $D/M = 1$, and using an approximation

$$\frac{t - t_c}{a} = \left(\frac{\partial t}{\partial \Theta}\right)_c$$

for the initial step, the temperatures along the first row may be determined, assuming that the pressure distribution is known. Substituting these newly established values, row 1, and the previous values, row 0, in equation (17),

Fig. 4.
Pressure and Temperature Distribution over a Sector Pad (Relaxation Method—Solution 2)

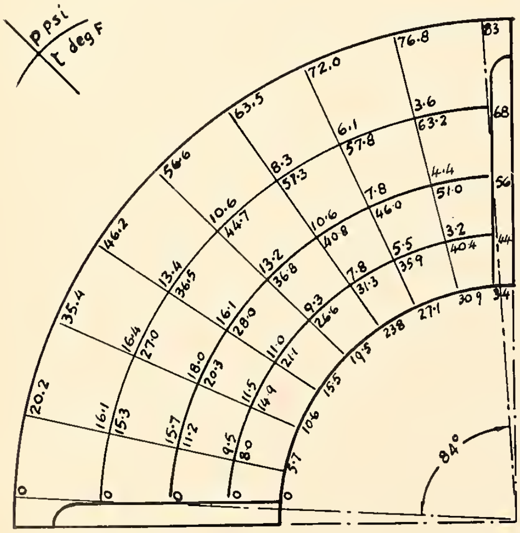
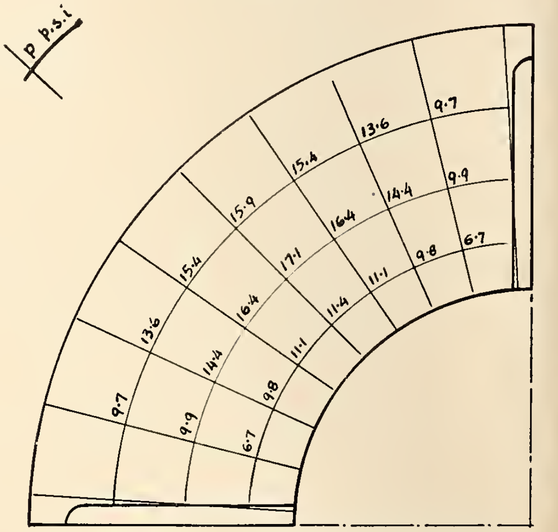


Fig. 5.
Pressure Distribution over a Sector Pad (Solution 3)



the temperatures in the succeeding row 2 may be obtained. Viscosity and density ratios, M and D, are obtained for each new set of temperatures from the appropriate viscosity and density curves for the particular oil used. Using this step-by-step procedure, temperatures are found along the length of the bearing.

To solve the problem completely, the two systems must be compatible. As a first approximation the pressure distribution is taken as zero all over the bearing, and the resulting temperature distribution is calculated, say t_1. Corresponding to a temperature distribution t_1, a pressure distribution P_1 is obtained by applying equation (16). Using the new pressure distribution P_1, a new set of temperatures t_2 is evolved and from it, a pressure distribution P_2. This process could be repeated indefinitely, but it is found that in general t_2 and P_2 are close to the required solutions.

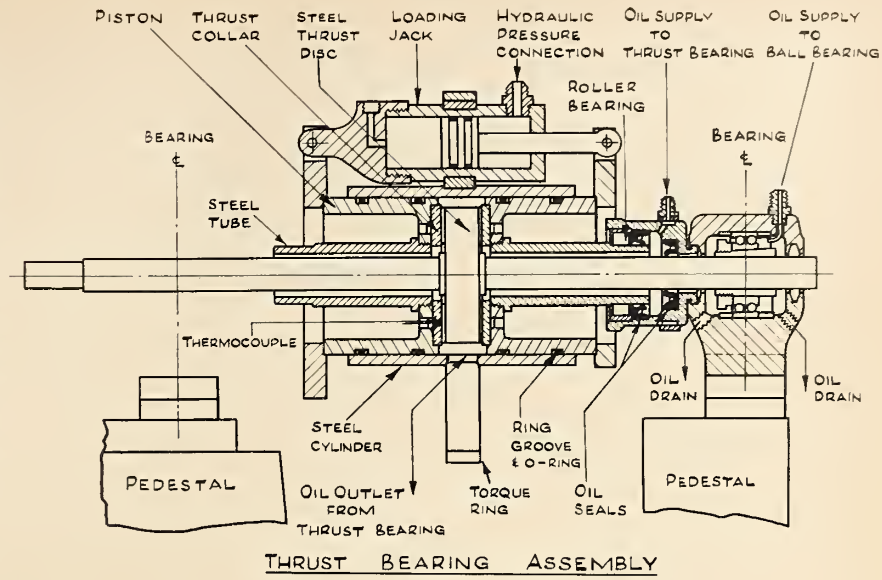


Fig. 6.

Load Carrying Capacity

The load carried by the sector pad is obtained by integrating the pressure over the area of the pad.

$$\text{Load } W \text{ per pad } = \int_{r_0}^{r_1}\int_0^{\alpha} pr\, d\theta\, dr \quad (18)$$

Changing the variables and limits of integration by the transforms previously employed

$$W \text{ per pad } = \frac{6v_0\omega\alpha\, r_0^{4}}{h^2}\int_0^{R1}\int_0^1 Pe^{2\alpha R} d\Theta\, dR \quad (19)$$

This may be integrated numerically over the equivalent rectangular area by an application of Simpson's 1/3 Rule in two directions.

Fig. 7. Thrust Bearing—2 Groove Bearing

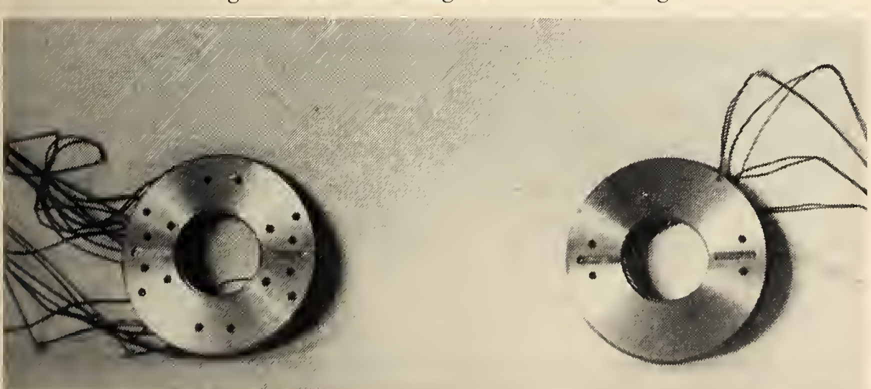
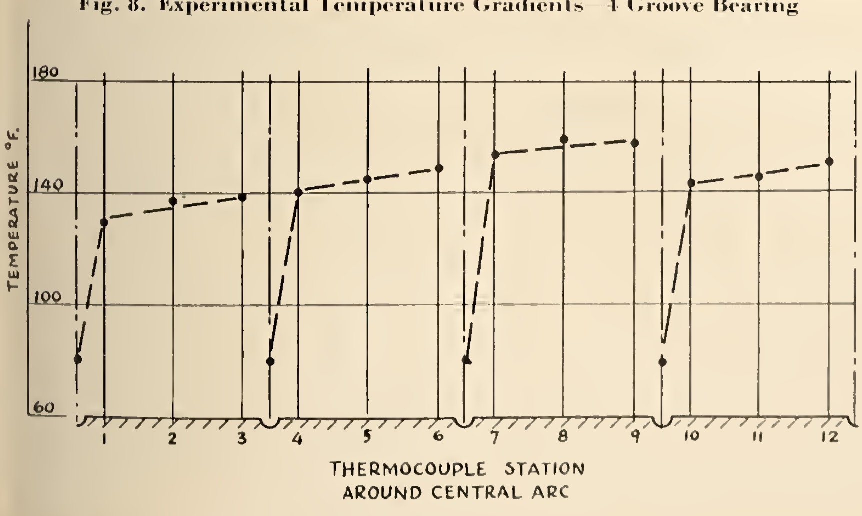


Fig. 8. Experimental Temperature Gradients—4 Groove Bearing



General Solution Taking Account of Side Leakage: In a parallel surface thrust bearing with a small number of grooves, the length-to-breadth ratio may be quite large and the effect of side leakage is considerable. Although numerical and computer solutions take side leakage into account, a separate calculation is required for each change in the running conditions of a given bearing. It is desirable, therefore, to derive a general solution which includes the effect of flow in two dimensions, even at the expense of making certain simplifications in other terms of the governing equations.

Consider a sector pad of a circular bearing, Fig. 1, for which the governing equations in polar co-ordinates are equations (12) and (13).

It is necessary to make two simplifications:

1. Assume constant kinematic viscosity, v/ρ. Although this assumption cannot be justified physically as the variation of viscosity with temperature is an important factor in the performance of a bearing, it is interesting to observe the effect of this assumption by making numerical comparison later with the previous two solutions.

2. Assume no variation of temperature in the radial direction. This assumption appears to be more reasonable in practice than in theory because it is observed experimentally that when steady running conditions are achieved, temperature gradients in the radial direction are small because of heat conduction in the bearing and runner surfaces.

Pressure Equation

Equation (12) can now be written

$$\frac{\partial^2 p}{\partial \theta^2} + r\frac{\partial}{\partial r}\left(r\frac{\partial p}{\partial r}\right) = Kr^2 g(\theta)$$

where $K = \dfrac{6\omega v}{h^2\rho}$ and $g(\theta) = \dfrac{\partial\rho}{\partial\theta}$

$$(20)$$

is a function of 'θ' only since ρ is independent of 'r', by assumption 2.

Boundary conditions are

$$p = 0 \quad \text{at} \quad r = r_0, r_1,$$

and $\quad p = 0 \quad \text{at} \quad \theta = 0, \alpha.$

This equation may be solved by the use of a Fourier sine transform.

By definition, let

$$\bar p_n = \int_0^\alpha p \sin\left(\frac{\pi n\theta}{\alpha}\right) d\theta \qquad (21)$$

then

$$p = \frac{2}{\alpha}\sum_{n=1}^{\infty} \bar p_n \sin\left(\frac{\pi n\theta}{\alpha}\right)$$

Multiply equation (20) by

$$\sin\left(\frac{\pi n\theta}{\alpha}\right)$$

and integrate between the limits $\theta = 0$, α, giving

$$-\left(\frac{\pi n}{\alpha}\right)^2 \bar p_n + r\frac{d}{dr}\left(r\frac{d}{dr}\bar p_n\right) = Kr^2\bar g_n \qquad (22)$$

where $\bar g_n = \displaystyle\int_0^\alpha g(\theta)\sin\left(\frac{\pi n\theta}{\alpha}\right) d\theta$

Solving for $\bar p_n$ the complementary function is

$$\bar p_n = r^{\pm\left(\frac{\pi n}{\alpha}\right)}, \; r^{\pm\left(\frac{\pi n}{\alpha}\right)}$$

and the particular integral is

$$\bar p_n = C_n r^2$$

where

$$C_n \text{ is } \frac{K\bar g_n}{4 - (\pi n/\alpha)^2}$$

Evaluating the constants of integration gives the solution (see top of page)

$$\bar p_n = \frac{K\bar g_n}{4 - (\pi n/\alpha)^2}\left[\left(\frac{r_0^{2+(\pi n/\alpha)} - r_1^{2+(\pi n/\alpha)}}{r_1^{2\pi n/\alpha} - r_0^{2\pi n/\alpha}}\right) r^{\pi n/\alpha} + \left(\frac{r_0^{2-(\pi n/\alpha)} - r_1^{2-(\pi n/\alpha)}}{r_1^{-(2\pi n/\alpha)} - r_0^{-(2\pi n/\alpha)}}\right) r^{-(\pi n/\alpha)} + r^2\right] \qquad (23)$$

provided that

$$(\pi n/\alpha)^2 \neq 4$$

This expression can be evaluated for any point on the bearing providing that $\bar g_n$ is known.

While density is essentially a function of temperature only since the pressures involved in this type of bearing are quite small, a reasonable first approximation is $\rho = \rho_0(1 + b\theta)$, assuming a linear increase of temperature around the bearing. Other more elaborate relationships between ρ and θ might be used here without altering the main part of the solution.

Thus $\qquad \dfrac{\partial\rho}{\partial\theta} = \rho_0 b$

and $\qquad \bar g_n = \dfrac{\rho_0 b\alpha}{n\pi}(1 - \cos n\pi) \qquad (24)$

This expression is zero for even values of "n", and is equal to

$$\frac{2\rho_0 b\alpha}{n\pi}$$

for odd values of "n".

For any point on the bearing, therefore, the pressure is

$$p = \frac{2}{\alpha}\sum_1^\infty \bar p_n \sin\left(\frac{n\pi\theta}{\alpha}\right)$$

for odd values of "n".

Introducing the value of $\bar p_n$ from equation (23) and substituting

$$r = kr_0 \quad \text{and} \quad r_1 = k_1 r_0,$$

this becomes

$$p = \frac{2}{\alpha}\sum_1^\infty \frac{K\bar g_n r_0^2}{(\pi n/\alpha)^2 - 4}\left[\left(\frac{k_1^2 - k_1^{-(\pi n/\alpha)}}{k_1^{\pi n/\alpha} - k_1^{-(\pi n/\alpha)}}\right) k^{\pi n/\alpha} + \left(\frac{k_1^{\pi n/\alpha} - k_1^2}{k_1^{\pi n/\alpha} - k_1^{-(\pi n/\alpha)}}\right) k_1^{-(\pi n/\alpha)} - k_1^2\right] \sin\frac{\pi n\theta}{\alpha} \qquad (25)$$

It is found that the series is rapidly convergent and p may be found by summing the first four or five terms only.

Load Carrying Capacity

As before, the load carried by the bearing is obtained by a double integration of the pressure over the sector area.

$$\text{Load } W \text{ per pad} = \int_{r_0}^{r_1}\int_0^\alpha r\frac{2}{\alpha}\sum_1^\infty p_n \sin\left(\frac{n\pi\theta}{\alpha}\right) d\theta\, dr \qquad (26)$$

This integration is easily carried out since $\bar p_n$ is independent of θ, to give

$$W \text{ per pad} = \frac{48\omega v_0 b\alpha r_0^4}{\pi^2 h^2}\sum_1^\infty \frac{1}{n^2[4 - (\pi n/\alpha)^2]}\left[\frac{k_1^4 - 1}{4} - \frac{\left(k_1^{\pi n/\alpha} - k_1^2\right)^2}{[(\pi n/\alpha) - 2]\;[k_1^{-(2\pi n/\alpha)} - 1]} - \frac{\left(k_1^2 - k_1^{-(\pi n/\alpha)}\right)^2}{[(\pi n/\alpha) + 2][1 - k_1^{-(2\pi n/\alpha)}]}\right] \qquad (27)$$

This summation also converges rapidly and can readily be evaluated by taking the first four or five odd values of "n".

It can be seen that the expressions for pressure and load consist of two parts, an infinite series which depends on the geometry of the bearing only, and a multiplying factor containing the terms depending on the operating conditions. Thus, for a given bearing the cumbersome series term requires to be evaluated only once, and subsequent changes in operating conditions do not affect this term. In effect this provides a general solution for a given bearing.

Temperature Distribution

Simplifications may be made in the energy equation by assuming a representative set of conditions for a high speed bearing and examining the orders of magnitude of the individual terms. In this way the terms containing $(\partial p/\partial r)^2$ and $(\partial p/\partial\theta)^2$ are found to be of the order 10^1 as compared to $\omega^2 r^2 v/h$ which is of the order 10^5 and $\partial t/\partial r$, itself probably smaller than $\partial t/\partial\theta$, has a coefficient of order 10^{-5} compared with the coefficient of order 10^{-2} for $\partial t/\partial\theta$. Thus the energy equation reduces to

$$\frac{\partial t}{\partial\theta} = \frac{\omega^2 r^2 v}{hJ\rho\sigma}\left\{\frac{1}{\dfrac{\omega h}{2} - \dfrac{h^3}{12v}\dfrac{1}{r^2}\dfrac{\partial p}{\partial\theta}}\right\} \qquad (28)$$

Substituting

$$\frac{\partial p}{\partial\theta} = \frac{2}{\alpha}\sum_1^\infty \bar p_n \frac{n\pi}{\alpha}\cos\left(\frac{n\pi\theta}{\alpha}\right)$$

gives an expression which can be evaluated for each point on the bearing, whereupon equation (28) may be integrated numerically to give the temperature distribution.

Numerical Comparison of Three Solutions

The three solutions are compared by applying each in turn to a bearing operating under the same set of running conditions, chosen arbitrarily but within the range of the experimental work described later.

The bearing is a parallel-surface sector thrust bearing having four pads, inner diameter 1.44 in., outer diameter 3.0 in., radial oil grooves 1/8 in. wide, giving an included sector angle $\alpha = 1.465$ radians.

The operating conditions are chosen to be:

Inlet temperature	=	100°F
Rotational speed	=	10,000 r.p.m.
Film thickness	=	0.001 in.

The lubricant is a light turbine oil with a viscosity-temperature relationship which is closely represented over the required temperature range by $\nu = \nu_0 e^{-\beta t}$, with $\beta = 0.02$ and the density-temperature relationship is

$$\rho = \rho_0(1 - \lambda t)$$

with $\lambda = 0.00043$.

Inlet viscosity ν_0	=	0.572×10^{-3} lb. sec./ft.^{2}
Initial density ρ_0	=	53.4 lb./ft.^{3}
Specific heat σ	=	0.45.

Solution 1—No Side Leakage: Since the derivation of this solution is in Cartesian co-ordinates for an infinitely wide bearing, the application to a circular bearing cannot be made directly. However, a good approximation to the temperature and pressure around the central arc (i.e. at the mean radius) is obtained by ignoring all radial effects and straightening the arc to give a slider bearing of length : mean radius × included angle. Taking the mean radius as 1.04 in., which is the value obtained in Solution 2, with an included angle of 1.465 radians, the length of the central arc is 1.52 in.

The parameter

$$G = \frac{2U\nu_0\beta}{h^2\sigma J\rho_0}\cdot\frac{\rho_0}{\rho_m}$$

is evaluated. Since the correct value of ρ_m cannot be determined until t_m is known, an initial value of G is obtained by taking $\rho_0/\rho_m = 1$. From this first approximation, a value of ρ_m is obtained from which the initial value of G may be adjusted. After two such adjustments G is found to be 16.3.

Thus the maximum temperature

$$t_L = (1/\beta)\ln(16.3L + 1) = 56.1°\text{F}$$

$$t_m = (t_L/2) = 28.05°\text{F}.$$

The general equation for temperature at radius 1.04 in. is

$$t = 50\ln(16.3x + 1)$$

The maximum pressure occurs at $x_m = 0.56$ in. from the inlet edge and $p_m = 63.8$ p.s.i. The general equation for pressure at radius 1.04 in. is

$$p = 0.082(56.1t - t^2)\ \text{p.s.i.}$$

These equations are plotted in Fig. 3.

Solution 2—Relaxation Method: Before the relaxation method can be applied to a sector pad the variables θ and r are transformed using

$$\theta = \alpha\Theta \quad \text{and} \quad r = r_0 e^{\alpha R}$$

whereupon the sector pad becomes rectangular, with boundaries, for this bearing, of

$$\Theta = 0 \quad \text{and} \quad 1,$$

$$R = 0 \quad \text{and} \quad \frac{1}{1.465}\ln\frac{1.5}{0.72} = 0.5$$

This rectangular area can be divided into an integral number of squares of side $a = 0.125$, or into a finer mesh if greater accuracy is required.

The temperature distribution for the bearing is obtained first from the finite difference equation (17). For the bearing dimensions and running conditions specified, the dimensional term is evaluated:

$$\frac{6\nu_0\omega\alpha r_0^2}{J\rho_0\sigma h^2} = 145$$

the units being temperature degrees per radian.

An initial pressure distribution, say $P = 0$ all over is assumed for the bearing, and the resulting temperature distribution obtained. The pressure equation (16) is applied to the grid and the

Fig. 9. Coefficient of friction f v. parameter ZN/p^1

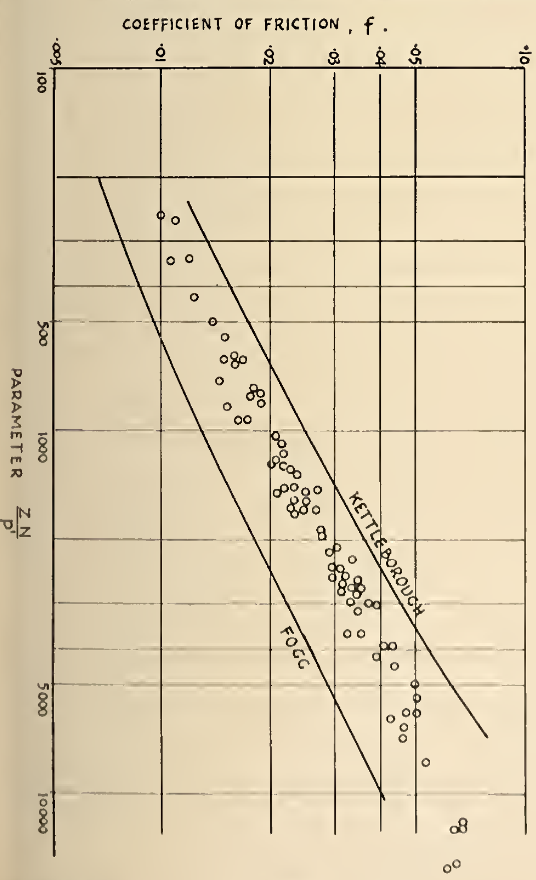


Fig. 10. Coefficient of friction f v. parameter ZN/p^1 r_0/h

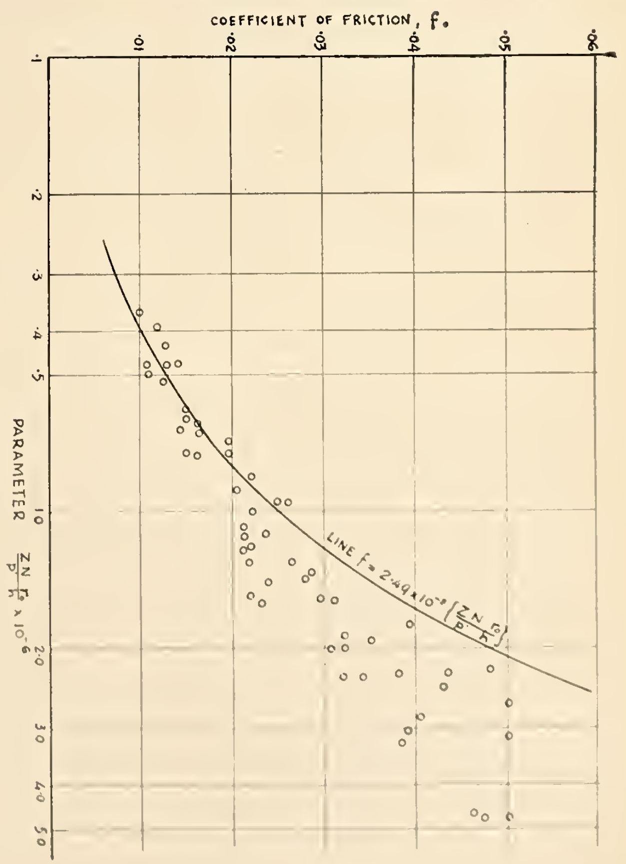


Table 1.

Summary of Calculated Values for 2-Pad and 4-Pad Bearings

		Solution 1		*Solution 2*		*Solution 3*	
Bearing Type		2 pad	4 pad	2 pad	4 pad	2 pad	4 pad
Temperature Rise	t°F	82.5	56.1	81.9	55.7	104	205
Maximum Pressure	p p.s.i.	139	63.8	18.4	18.0	11.7	17.1
Bearing Load	W lb.	—	—	27.7	37.7	29.2	40.2

values of the residuals F_C and the influence coefficients a_{cn} and a_{cc} are calculated for each intersection C in terms of the surrounding four points. The assumed pressure distribution $P=0$ is now altered throughout the bearing until the residuals are reduced to negligible quantities. This process may be repeated and it is found that the second temperature and pressure distributions are very little different to the first values, since the pressures are quite small, and have little effect on the temperatures. Thus the values after the second relaxation may be taken as the final solution, and these values are shown in Fig. 4.

The total load-carrying capacity for a four-pad bearing, by numerical integration of the pressures of Fig. 4, is 37.7 lb.

Solution 3—General Solution including Side Leakage: The general expression for the pressure at any point on the surface of a bearing sector is given by equation (25). Introducing the values of K from equation (20) and g_n, equation (24), the pressure may be evaluated provided that b, the expansion coefficient related to bearing angle is known. By definition,

$$\rho = \rho_0(1 + b\theta) = \rho_0(1 - \lambda t)$$

Thus $b = -0.00043(t/\theta)$.

Using the temperature equation from Solution 1, which is later seen to be quite accurate, the temperature rise around a four-pad sector at the mean radius 1.04 in., is 56.1° for an angle $\alpha = 1.465$ radians. Than $b = -0.0165$.

The average viscosity is

$$v_{av} = \frac{1}{t}\int_0^t v_0 e^{-\beta t}\,dt$$

$$= 0.343 \times 10^{-3} \text{ lb.-sec./ft.}^2$$

Equation (25) can now be evaluated over the sector pad for each point on a grid, and the pressure distribution is shown in Fig. 5. It may be noted that the summation term depends only on physical dimensions and is evaluated only once for a given bearing.

The load per pad is found from equation (27) by a similar procedure, and the total load carried by a four-pad bearing is 40.0 lb.

The temperature distribution obtained by this method is not satisfactory, because the assumption of constant viscosity appears to have a much greater detrimental effect on temperature values than on pressures. However, it is included here to complete the comparison. Upon evaluation of equation (28), it is found that for the given conditions the term containing $\partial p/\partial\theta$ is very small, thus the temperature equation becomes:

$$\frac{\partial t}{\partial \theta} = \frac{2\omega r^2 v}{h^2 J\rho\sigma} \qquad (29)$$

This expression has been integrated for $r = 1.04$ in. by a finite difference method similar to that used in Solution 2.

The pressure and temperature curves at the mean radius for the three solutions are shown in Fig. 3, and a numerical comparison of maximum pressures and load-carrying capacity is shown in Table I for the four-pad bearing and a two-pad bearing of the same diameter.

From this and other comparisons and assuming the relaxation solution to be accurate, it would appear that the assumption of no side leakage, but with viscosity as a variable, as in Solution 1, gives a good estimation of temperatures but very high pressure values.

On the other hand, a solution which includes the effect of side leakage but assumes a constant viscosity, such as Solution 3, gives a good approximation for maximum pressures and load-carrying capacities, but is greatly in error for temperature values.

It is proposed therefore to use the following equations in the analysis of the experimental work.

Temperature: from Solution 1

$$t = \frac{1}{\beta}\ln(Gx + 1) \qquad (9)$$

Pressure: from Solution 3

$$p = \frac{2}{\alpha}\sum_1^\infty \bar{p}_n \sin\left(\frac{n\pi\theta}{\alpha}\right) \qquad (25)$$

Load-Carrying Capacity: from Solution 3

$$W \text{ per pad} = \int_{r_0}^{r_1} \frac{4r}{n\pi}\sum_1^\infty \bar{p}_n\,dr \qquad (27)$$

for $n = 1, 3, 5 \ldots$ etc.

Friction in a Parallel-Surface Bearing

For any plane thrust bearing the shear stress at any point in a fluid film is

$$\tau = \frac{v\omega r}{h} + \frac{dp}{d\theta}\frac{h}{2} \qquad (30)$$

The total shear force is

$$F = \int_0^\alpha \int_{r_0}^{r_1}\left[\frac{v\omega r}{h} + \frac{dp}{d\theta}\frac{h}{z}\right] r\,dr\,d\theta \qquad (31)$$

Integrating the second term by parts, and noting that $p = 0$ at the boundaries then

$$F = \int_{r_0}^{r_1}\left[\frac{v\omega r}{h} - \frac{p}{2}\frac{dh}{d\theta}\right]\alpha r\,dr \qquad (32)$$

For a parallel-surface bearing $dh/d\theta$ is zero, thus, using an average value for viscosity, the friction force becomes

$$F = \frac{\omega v_{AV}}{h}\frac{\alpha(r_1^3 - r_0^3)}{3} \qquad (33)$$

The bearing load

$$W = \frac{\alpha}{2}(r_1^2 - r_0^2)p^1$$

where p^1 is the load per unit area.

The ratio of tractive effort to load capacity, commonly called the coefficient of friction, is

$$f = \frac{\omega v_{AV}}{p^1}\frac{r_0}{h}\frac{2}{3}\frac{(k_1^3 - 1)}{(k_1^2 - 1)} \qquad (34)$$

This is similar to the Petroff equation for a lightly loaded journal bearing.

Experimental Apparatus

The experimental equipment is shown in Fig. 6.

The central high-speed shaft, having a speed range between 4400 and 16,000 r.p.m., carries a 3 in. diameter steel thrust disc shrunk on and machined in position on the shaft. This shaft runs in two double-row self-aligning ball bearings.

Surrounding the thrust disc and shaft is a steel cylinder carrying on the outside three matched hydraulic jacks set in parallel at 120° around the periphery. These jacks are connected to triangular end plates, which bear against two opposing pistons in the steel cylinder. The loading pistons carry two similar white-metalled thrust collars which act against the opposite faces of the central high-speed disc. Great care is taken in machining and assembly to ensure that the bearing faces remain flat and parallel, within engineering limits. The whole cylinder and piston assembly is torque-mounted and supported by two steel tubes which attach to the loading pistons and extend to roller bearings at their outer ends.

Oil supply to the thrust faces is fed to the end bearing supports and through the annular space between the high-speed shaft and the piston tubes to the inner diameter of the bearings. The oil supply pressure was constant at about 5 p.s.i.

Temperatures around the bearing are easured by a number of thermo-)uples set in non-conducting plugs and pped flush with the bearing surface of e thrust plate. The other thrust plate left free from disturbance except for eck thermocouples at the inlet and itlet of each pad, as in Fig. 7. This rangement indicates if the interrup-)n of the bearing surface by a large imber of thermocouples, although ted flush, affects the operation of the earing. In fact, there was little differ-ice between the two faces, although in neral the side with the large number of ermocouples ran a few degrees cooler, obably due to conduction along the ermocouple leads.

The measurement of film thickness is effected by four 0.0001 in. dial uges, two gauges reading the displace-ent of the loading pistons relative to ch other, and two measuring absolute splacements relative to the fixed sup-rts of the apparatus. Average film ickness values and cross-checks on curacy were thus obtained.

Thermal expansion and distortion fects were serious, in the same order of agnitude as the film thickness values, it these were overcome by taking zero adings on the dial gauges immediately ter stopping the test while the machine is still hot. When the apparatus oled, the dial gauges returned to their iginal setting, indicating no perma-int deformation or slippage during the t.

The various advantages of this design are that no end thrust is applied to the high speed support bearings; the bearing faces are accessible for thermocouples or other measuring devices for pressure or for film thickness; extraneous friction torques (due only to the non-rotating roller bearings and light oil seals) are small and independent of load and speed, allowing accurate measurements to be made of the friction at the test bearing.

Experimental Results

Tests were conducted on flat bearings having two, three and four grooves. The bearing plates had the same dimensions and the lubricating oil, Turbo 27, had the same characteristics as the hypothetical bearing described earlier in the paper.

Temperature Gradient: The temperatures recorded around the central arc for a typical test are shown in Fig. 8. It may be seen that a simple temperature gradient is not obtained, but that there is a rapid rise from oil inlet temperature to the temperature shown by the first thermocouple, and thereafter a rather flat temperature gradient around the pad.

It would appear that two factors influence the temperature readings. The actual oil temperature at the inlet edge of the pad is almost certainly higher than the recorded inlet oil temperature, which was measured by a thermocouple placed in the annular supply space. Since a certain amount of oil is carried around the bearing there will be a mixing in the grooves of fresh oil and recirculating oil, raising the temperature of the inlet oil.

It is also thought that the accepted assumption of adiabatic conditions in the oil film does not describe the actual mechanism of heat flow. It appears from the measured temperatures that the shaft and bearing reach a steady high temperature and thereafter there is rapid heating of the thin film of oil by conduction from the metal surfaces.

Friction: In accordance with the observed temperature distribution, the average viscosity, Z centipoise, is taken as the value at the maximum bearing temperature.

As a correlation with other experimenters, Fogg[2] and Kettleborough,[6] the coefficient of friction is plotted against ZN/p^1, Fig. 9. It is seen that the results fall on a line having substantially the same slope on a log-log curve as the other curves, being below Kettleborough's results and showing higher friction values than Fogg.

The parameter ZN/p^1 is strongly influenced by the value taken for the average viscosity Z, and the discrepancies in the curves of Fig. 9 are probably in good part due to the different methods employed to determine Z.

In Fig. 10, the coefficient of friction, f, is plotted against the correct non-dimensional parameter for a parallel bearing, $(ZN/p^1)(r_0/h)$. The experi-

Fig. 11a, 11b, 11c. Film Thickness h v. parameter $\left[\omega/\left(\frac{1}{v_L} - \frac{1}{v_0}\right)\right]^{1/2}$

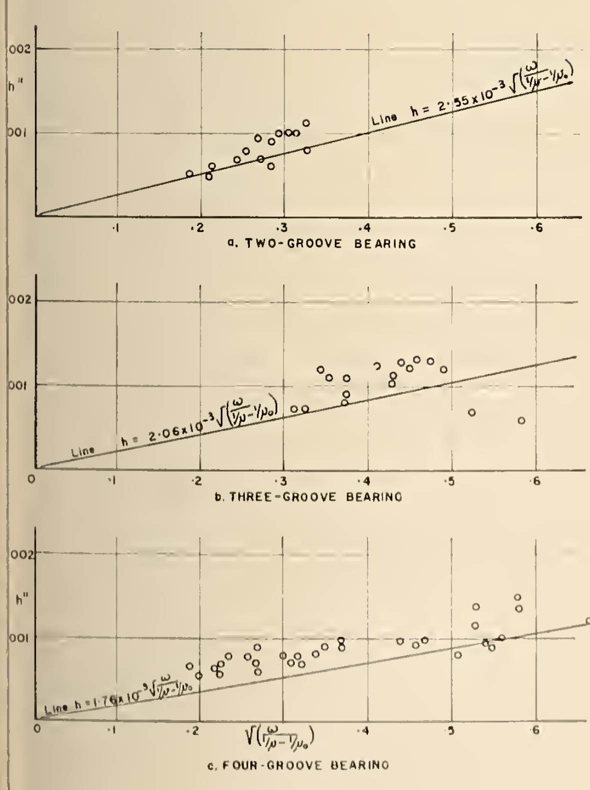
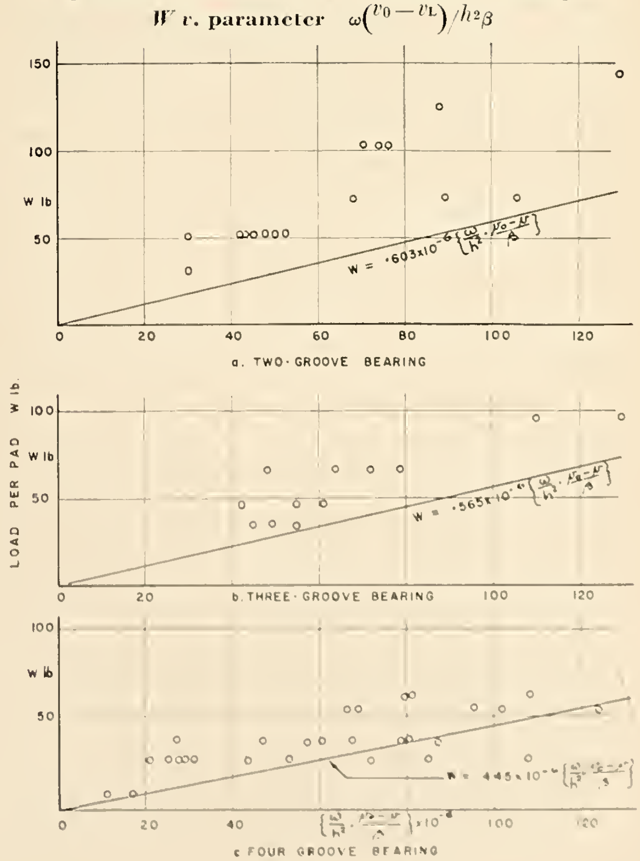


Fig 12a, 12b, 12c. Load Carrying Capacity per pad W v. parameter $\omega\left(v_0 - v_L\right)/h^2\beta$



mental results can be compared with the theoretical equation for this particular bearing.

There is a marked scatter in the experimental points, due to the small value of h in the denominator, but agreement is good at low values of $(ZN/p^1) \cdot (r_0/h)$. At higher values of $(ZN/p^1) \cdot (r_0/h)$ the theoretical and actual curves begin to diverge, indicating that the constant viscosity assumption used in deriving the friction equation is not adequate at high speeds.

Several instances of non-fluid-film lubrication were noted during the course of testing, characterized by vibration and unstable temperatures. The obviously mal-functioning tests were discarded, but it was observed that some of these tests did not show much higher coefficients of friction than tests running under fluid film conditions. Unlike the journal bearing, there does not appear to be a well-defined transition between hydrodynamic and boundary lubrication for the parallel surface bearing. This can be explained when one considers that in a journal bearing, when the film thickness diminishes, metal-to-metal contact takes place along a very narrow linear area, with high pressure and positive contact; whereas with the parallel surface bearing, when the film thickness is of the same order of magnitude as the surface roughness, it will be possible to have film lubrication with intermittent contact of asperities over the whole surface, at low metal-to-metal pressures.

Film Thickness: Although equation (9) does not represent the actual temperature distribution around the bearing, it appears to be accurate in estimating the total temperature rise. Substituting for G and rewriting equation (9) gives an equation for the film thickness

$$h = \left(\frac{\omega}{(1/v_L) - (1/v_0)}\right)^{1/2} \left(\frac{2\beta r^2 \alpha}{\sigma J \rho_m}\right)^{1/2} \tag{35}$$

In Figs. 11, *a*, *b* and *c*, the values of h are plotted against

$$\left(\frac{\omega}{(1/v_L) - (1/v_0)}\right)^{1/2}$$

and compared with the theoretical curves for two-, three- and four-pad bearings. Again, because of the very thin films being measured, the experimental scatter is pronounced but correlation between the measured values and the calculated curves is reasonable.

Load-Carrying Capacity: The load-carrying capacity from equation (27) can be written as

$$W \text{ per pad} = \frac{\omega}{h^2}\left(\frac{v_L - v_0}{\beta}\right) C$$

and with h in inches the constants C are

0.603×10^{-6} for a 2-pad bearing
0.565×10^{-6} for a 3-pad bearing
and 0.445×10^{-6} for a 4-pad bearing.

The experimental results are compared with these theoretical equations in Figures 12, *a*, *b* and *c*. In these cases, experimental scatter is even more pronounced due to the fact that the parameter

$$\frac{\omega}{h^2}\left(\frac{v_0 - v_L}{\beta}\right)$$

involves h^2 term in the denominator. The agreement between experiment and theory is questionable, and the most that can be claimed is that both are of the same order of magnitude.

Conclusions

As a point of departure, it has been accepted that two equations, a general expression of Reynolds equation and an energy equation, govern the hydrodynamic behaviour of a parallel surface thrust bearing. By solving these equations in three different ways and comparing calculated results, it is seen that the assumption of no side leakage in a theoretical analysis produces temperature values which are comparable with the more correct numerical solution, but that pressures from this solution are too high. A solution which assumes constant viscosity, but includes the effect of side leakage, leads to a close approximation for pressures and load-carrying capacity, but temperatures are greatly in error.

The temperatures recorded indicate that a temperature difference exists between the inlet and outlet edges of a bearing pad, and this temperature difference is sufficient to produce the loads carried by the bearing. In this bearing, a maximum load per unit area of 70 p.s.i. required a temperature rise of 150°F and a film thickness of 0.0005 in. For the very high bearing pressures reported by Fogg[2], it is estimated that a temperature rise of 300°F and a film thickness of 0.0002 in. would be required in a bearing running at 10,000 r.p.m. While these values are not impossible to achieve in a laboratory, they would not be readily maintained in practical applications. A simple temperature gradient around the bearing pad was not obtained, and it is believed that the adiabatic assumption used in developing the original energy equation is open to question.

The experimental results which are presented show a marked scatter, due to the difficulty encounted in obtaining accuracy in certain measurements, notably film thicknesses which are very small, and average viscosity values which are ill-defined. In spite of this scatter, sufficient correlation exists between the experimental results and the theoretical equations which have been developed, to state that thermal wedge lubrication does occur within the range of test conditions.

It would appear, therefore, that while the thermal wedge effect does exist and is appreciable in parallel surface thrust bearings at low loads and high speeds, high load-carrying capacity requires high temperature gradients and very thin oil films which cannot be achieved in normal engineering practice. In addition, the parallel surface thrust bearing is somewhat unreliable, the transition from hydrodynamic lubrication and stable operation to boundary lubrication, metal contact and unstable temperatures taking place easily and in an indefinite manner.

Acknowledgements

The experimental work of this paper was carried out at the Royal College of Science and Technology, Glasgow, and the writer is indebted to Professor A. S. T. Thomson for the facilities made available.

The work on high speed lubrication is being continued in the Lubrication Laboratory, Department of Mechanical Engineering, The University of British Columbia, under the auspices of a National Research Council Operating Grant.

Notation

U = Velocity of moving surface
p = Pressure
ρ = Density
v = Viscosity
h = Film thickness
t = Temperature above inlet
J = Joule's Equivalent
σ = Specific Heat
λ = Coefficient of Thermal Expansion
β = Temperature—Viscosity Coefficient
τ = Shear Stress
ω = Angular Velocity
α = Included Angle of a Sector Pad
b = Expansion Coefficient related t[o] Bearing Angle
L = Length of bearing.

Any symbol which is not listed i[s] defined where it first appears.

References

1. Newbigin, H. T. 'The Problem of th[e] Thrust Bearing,' Proc. I.C.E. vol. 19[6] p. 223. 1914.
2. Fogg, A., 'Fluid Film Lubrication o[f] Parallel Thrust Surfaces,' Proc. I. Mec[h.] E. vol. 155, p. 49. 1946.
3. Cope, W. F. 'The Hydrodynamica[l] Theory of Film Lubrication,' Pro[c.] Royal Soc. vol. 197A, p. 201, 1949.
4. Osterle, F., Charnes, A., Saibel, E[.] 'Solution of the Reynolds Equation f[or] Slider-Bearing Lubrication — VI,' Tran[s.] A.S.M.E., vol. 75, p. 1133, 1953.
5. Christopherson, D. G. 'A New Mathe[-] matical Method for the Solution o[f] Film Lubrication Problems,' Proc. [I.] Mech. E. vol. 146, p. 126, 1942.
6. Kettleborough, C. F. 'Tests on Parall[el] Surface Thrust Bearings,' 'Engineering[,'] p. 174, August 5, 1955.

A RESEARCH VIEWPOINT ON

ENGINEERING EDUCATION

Dr. B. G. Ballard, HON. M.E.I.C.,
Vice-President (Scientific)
National Research Council, Ottawa

WEBSTER DEFINES a university as "an institution organized for teaching and study in the higher branches of learning, and empowered to confer degrees in special departments". To define a university as an intellectual centre would probably be more appropriate. A university has a responsibility to develop new knowledge, and it should not be content merely to impart to its students the accumulation of past knowledge. The graduates should be imaginative and have the capacity for original thought. The university has two roles: first, to select the students who have this capacity, and second, to stimulate their originality and to provide them with the essential basic tools with which to create new intellectual structures. Anything less is not a university. Today, more than ever, a heavy responsibility devolves upon all professional people. It is to them that the world looks for leadership. The world cannot stand still, and advances are the product of creative minds.

In the main, Canadian universities have met their obligations well. Until recently, Canada was a pioneer country. There was an urgent demand for men and women trained to solve the immediate problems—problems which were well delineated. It was necessary to build roads, bridges, waterways, electric plants, transmission lines, sewers, water works, railroads, and communication systems. Canada's sons had served her well, and not the least of these were her engineers. Her public works were a credit to her. Canadian engineers made names for themselves. Mining engineers were in world-wide demand, electrical engineers pioneered in high voltage transmission, civil engineers distinguished themselves. The Shanly brothers completed the Hoosac Tunnel where United States engineers had failed; Thomas Coltrin Keefer built what was at that time the world's longest suspension bridge; Stanislaus Gzowski, Samuel Keefer, Killaly, Douglas, Cumberland, and Sir Sandford Fleming—all are famous. Some of these engineers came to Canada from Europe, but many of them were born and trained in Canada.

The universities were an essential part of this growth, and the engineering faculties of those universities deserve the highest credit. However, conditions have changed. Canada has emerged from the status of a colony to that of a nation. Secondary industries are being developed, and there exists a need for an entirely new type of engineer. We are now in a highly competitive era, and if we are to survive as an industrial nation, we must be at least as original in our thinking as our competitors. The fact that we possess a wealth of natural resources is not enough. There is evidence already that, in some respects, the engineers have been outstripped by the scientists to the extent that they have not been able to take full advantage of scientific advance. This became very evident during World War II and after, when it was necessary to recruit physicists to do much of the engineering work on radar and atomic energy.

It is imperative, therefore, that we, as an industrial nation, keep abreast of technological development. Where rule of thumb methods succeeded in an earlier era, we now require a scientific attack on our problems, bringing to bear the latest information in physics, chemistry, and metallurgy, and employing the best mathematical techniques. We must produce equipment which operates at high efficiency and can be manufactured at minimum cost. Failure to do so will deny us access to world markets of manufactured products. If we are content to export only raw or unprocessed materials, we become hewers of wood and drawers of water. Most disastrous of all, we will drive from our country the cream of our young men and women who have a compelling need for intellectual expression. There is no magic way to compete in world markets without putting forth the same ingenuity, enterprise and drive as our competitors.

It is not suggested that our universities should engage in the development of specific hardware. Rather, they have an obligation to produce men who can develop this hardware, men who are prepared to explore beyond our present frontiers of knowledge, men who have the capacity to bring new ideas to fruition. The man who can contribute to industry only as much as he has learned at university will fail to fulfil our needs. If you question this, merely reflect that many of the developments which we now take for granted were unknown in the author's undergraduate days. There was no radar, no TV, no trans-Atlantic telephone cable; there were no transistors, no electric phonographs, no Diesel locomotives, no space vehicles; radio broadcasting had barely emerged, and was in a highly undeveloped state. Many of these devices were the products of minds of men who had learned nothing about them in university, but they possessed the basic mental equipment which enabled them to

create new concepts. The rapidity with which new ideas emerge is emphasized by a statement of a large electronics firm that more than 70% of present sales have been developed within the last five years.

It has been stated that England's industrial strength of a half century ago was the direct result of the formation of the Royal Society. Only a few engineers, men like Smeaton for example, were Fellows of the Royal Society, but the Royal Society did provide the basic science which enabled the engineering profession to make such gigantic strides.

Very early in our history we had relied entirely on foreign countries for our higher education, and until 50 years ago, we relied on the United States and Europe for postgraduate training. In more recent years, however, Canadian universities have become important centres, and are "well on the way towards competing with the best institutions in other countries".

However, not all Canadian universities can take pride in meeting the new demands in engineering, although the overall position is encouraging. Too many universities look upon research, and particularly research in engineering, as an extracurricular luxury. In the author's opinion, if the university is to discharge its fundamental obligation, research must be an inherent part of its operation. It is not conceivable that the men Canada needs can be produced without a training in research. It is not conceivable that graduate studies can be divorced from research. Even in those cases where M.Sc. students do not participate actively in a research program, it is important that they should live in an environment of research and that they should learn the need for, and the excitement of, intellectual exploration. They must learn that they cannot rely on the design criteria of the past. They must develop new design techniques. They must be quick to take advantage of all the newest processes and all the newest materials. They must provide the foundation of science for progressive engineering.

President DuBridge of the California Institute of Technology once stated that "an inquiring mind must be the chief possession of university people". It should be emphasized again and again that the main purpose of a university is to develop creative people, and this process demands a strong interplay between student and staff. Research should be conducted within the framework of the academic departments to achieve this end, and, in the author's opinion, a separate organization or institute devoted primarily to research frequently fails to provide the necessary environment. It is desirable that the departmental staff should promote the research and have a direct responsibility for both graduate and undergraduate instruction. A further weakness of the separate organization is the tendency to become isolated. Workers fail to maintain communication with their contemporaries, and sometimes work is continued long after fruitful results have ceased.

The difficulties of financing research in universities are well recognized, but each university must acknowledge that research is an essential part of its responsibility, and that it should expect to support research facilities. In the past, the universities have been so preoccupied with the training of practicing engineers who could meet the immediate problems of the nation, that research was neglected, and this developed into a fixed pattern. Engineering faculties find now that they have less money available for research than the faculties embracing science and the humanities. In those fields, research has become a tradition, and it is imperative that engineering develop a similar tradition. Another problem which has arisen results from the ease with which university engineering staff and students can find employment outside of the academic theatre, and both find it more lucrative to devote themselves to more practical problems than to intellectual speculation. The situation is not so true of other disciplines, but a keen research man will derive so much satisfaction from research that he will not want to leave his laboratory. Moreover, he will encourage his better students to forego the immediate advantages of attractive remuneration for the more lasting satisfaction of a stimulating and rewarding career.

Undoubtedly, there is a variety of opinion regarding the extent to which a university can support research. All universities acknowledge their fundamental obligation to provide teaching facilities. They should assume also an obligation for research, and provide library, work shop, computation and any of the other ordinary services which are essential components. Universities should take full advantage of the various sources of support for research, giving preference at all times to those sources which impose a minimum of restriction. There are private sponsors who con[tribute] generously to research pro[grams]. Industry plays a not insignifi[cant] part, but municipal, provincial and federal governments provide th[e] bulk of the support. It is made avail[able] in several forms, but mainl[y] through scholarships which enabl[e] students to participate in research pro[grams] at the university, and throug[h] grants in aid of research enablin[g] staff members to pursue projects o[f] special interest to them, and to hir[e] graduate students to assist in thes[e] research projects.

The research or developmen[t] contract is also an important source and it has become popular in th[e] United States. However, it possesse[s] some weaknesses. It is usually directe[d] toward short term research for whic[h] some immediate objective is en[visaged], and thereby precludes th[e] exploration of those many interestin[g] areas for which no practical applica[tion] can be foreseen. Through th[e] ages these latter projects have yielde[d] the most profitable returns. If a stu[dent] is exposed to this type of sup[port] too extensively, he may fail t[o] appreciate the true significance of re[search]. The main attraction of the de[velopment] contract is that it usuall[y] makes provision for salaries and over[head], which are denied in the case o[f] a government grant. The researc[h] and development contract also tend[s] to divorce the project from the uni[versity], and this is particularly tru[e] where the project is of a classifie[d] nature.

There is one other possibl[e] means of support, and this is throug[h] the postdoctorate fellowship schem[e] financed by the federal governmen[t]. As university departments develo[p] their research, they can absorb effec[tively] postdoctorate fellows in [a] mutually beneficial way.

It was indicated earlier that th[e] progress of engineering research i[n] recent years has been encouragin[g]. It is interesting to note that the ex[penditure] of the National Researc[h] Council on engineering researc[h] grants has increased threefold in th[e] period 1958-1961. In 1961, well ove[r] $1 million was assigned to enginee[r]ing and earth sciences, which repre[sents] approximately 23% of the tot[al] NRC grants for all sciences, excep[t] medicine. Engineering has bee[n] awarded an increasing percentage o[f] the total NRC grants in aid of re[search] over the past few years, an[d] as research develops in engineerin[g] faculties, a still further increase ma[y] be expected.

Recent Development In Automatic Electrode Boilers

M. Eaton, M.E.I.C., *Consulting Electrical Engineer*

THE AUTOMATIC electrode boiler discussed in this paper is deeloped from the Kaelin electric boiler escribed in earlier publications.[1] It a result of a continuation of the evelopment described in an earlier aper.[2]

High voltage electrode boilers of ie Kaelin design have a number of nperfections that tend to limit their uitability for utilizing off-peak hydrolectric power. For example, (1) their iinimum safe load is about 15% of ieir rated capacity, (2) except in ery large sizes and with exceptionally ure feedwater, they can not be oprated satisfactorily at voltages as igh as 13.2 kv., (3) their electrode fe is not all that could be desired, nd (4) they are not economically dapted to the use of adequate autoiatic control equipment.

lectrical Characteristics

Electric boilers of the class reerred to in this paper have their electrodes normally partially submerged in the boiler water. Steam is raised by the energy dissipated in the water by its electrical resistance. For a three-phase, three-electrode boiler the power input is

$$P = 3I^2R \times 10^{-3}\text{kw} \qquad (1)$$

I is the electrode current in amperes, and R is the resistance in ohms of the circuit through the water between the electrodes and a common neutral which is grounded by a steel shell completely or partially surrounding each electrode.

Fig. 1 shows schematically a cylindrical electrode suspended in boiler water. A cylindrical ground shell 3 serves to obtain uniform current density on segments of the electrode, measured vertically, and to protect the outer pressure vessel 1 from corrosion by electric current.

By integration it may be shown that the resistance per unit height of the cylindrical body of water between water levels WL3 and WL4 is

$$R_t = \frac{\rho_t}{2\pi}\log_e\frac{B}{A}\ \text{ohms} \qquad (2)$$

R_t is the water resistance and ρ_t is the resistivity of the water at saturation temperature t.

Similarly it may be shown by integration that the resistance of the hemispherical body of water of mean radius L below WL3 and in contact with the hemispherical electrode tip of radius M is

$$R_t = \frac{\rho_t(L - M)}{2\pi LM}\ \text{ohms} \qquad (3)$$

The conductivity of water rises with its temperature in accordance with the following equation:

$$\gamma_t = \gamma_{68} + 0.025(t - 68)\gamma_{68}\ \text{micromho-cms} \qquad (4)$$

γ_t is the conductivity at saturation temperature t and γ_{68} is the conductivity at 68°F or 20°C.

Laboratory instruments are made and calibrated for measuring conductivity at 20°C. Resistivity is the reciprocal of conductivity. If units are changed, a suitable conversion factor is introduced. For example

$$\rho_t = \frac{0.394}{\gamma t} \times 10^6\text{ohm-in} \qquad (5)$$

Steam Resistance Factor

Steam bubbles in the boiler water increase the electrical resistance of the circuit as shown by the steam resistance factor, Fig. 2. As the B/A ratio is increased the potential gradient between electrode and neutral becomes such that an increasing proportion of the steam is raised near the electrode where the resistance imposed by the steam bubbles is greatest. This accounts for the slope of the curve.

The steam resistance factor may be defined as the ratio of the resistance of the circuit to neutral, determined by equation (1), to the calculated resistance corresponding with the indicated water level on the electrodes and with no allowance for the resistance imposed by the steam.

ig. 1. Sectional view of a Kaelin boiler howing an electrode suspended in the oiler water.

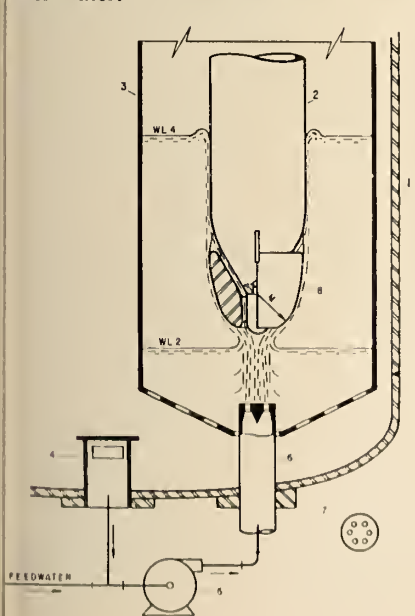
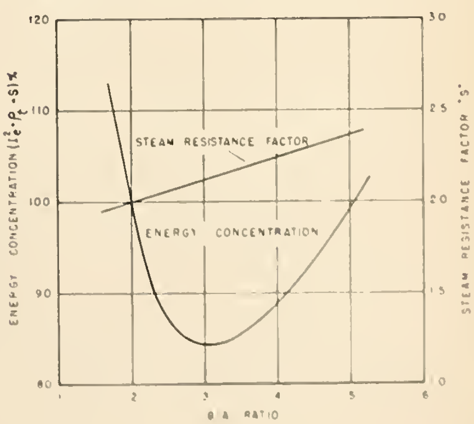


Fig. 2. Showing the relation between the B/A ratio and (1) energy concentration at the electrodes (2) the steam resistance factor.



The resistance imposed by the bubbles of steam would tend to be greater near the surface of the water surrounding the electrodes than at lower levels. There is, however, a compensating effect. The bubbles of steam decrease the weight per unit volume of water, thus causing the water to rise higher on the electrodes than the indicated level. Because of this rise in water level electrodes must be made longer than would otherwise be necessary.

Fig. 3 shows calculated voltage gradients, with no allowance for steam resistance, and corresponding hypothetical voltage gradients resulting from the resistance imposed by steam bubbles. Curves 2A and 2B indicate that little would be gained in circuit resistance by making dimension L greater than 3 M.

Energy Concentration

In equation (1) above the circuit resistance $R = R_t.S$ ohms and the energy concentration at the surface of the electrode $P_e = I_e^2.\rho_t.S$ watts/cu. in.
I_e is the current density in amps/in^2 and ρ_t is the resistivity of the boiler water in ohm-ins at saturation temperature.

Fig. 2 shows that with dimension A variable minimum energy concentration on the vertical sides of the electrodes is obtained when the electrode diameter is such that the ratio B/A is about 3/1.

It may be shown by calculation that the energy concentration on the hemispherical tips of the electrodes is theoretically less when M equals A than it is for shorter M dimensions, and with M equal to A the energy concentration on the hemispherical tips is about three times greater than it is on the vertical sides of the electrodes. Voltage gradients, see Fig. 3, also show that the energy concentration in the water surrounding the electrodes is at a maximum at the electrodes.

As long as the steam in the water remains in the form of bubbles it serves a useful and essential service in raising the electrical resistance of the circuit. If, however, the energy concentration at the electrode tips, where it is greatest, exceeds a critical value, steam envelopes will form through which the electric current makes arcing contact with the electrodes, thus causing electrode corrosion and unstable boiler operation.

Waterspout Action

Waterspout action may be defined as the process of taking water from the boiler, mixing the feedwater with it, and spouting the mixture up and around the tips of the electrodes. Equipment for this process is shown schematically in Figs. 4 and 5.

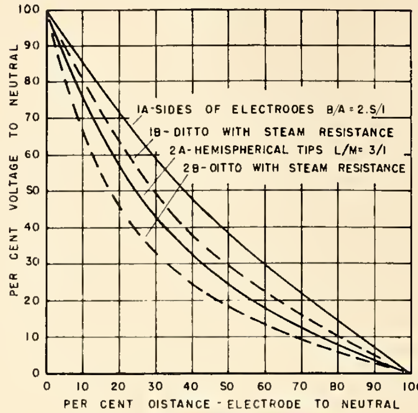


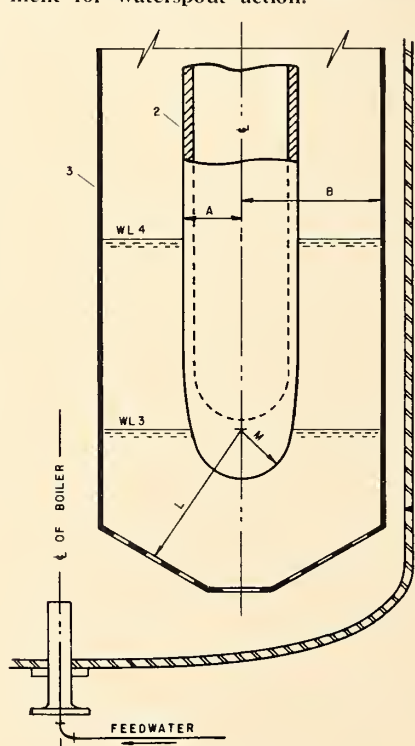
Fig. 3. Voltage gradients.

Advantages in the use of waterspout action are: (1) the permissible value of energy concentration at the electrode tips is greatly increased and (2) the spouted water maintains an electric circuit, allowing the water level to fall below the electrodes without a flashover occurring even with operating voltages as high as 15 kv.

This improvement in operating conditions permits a boiler to be operated either with feedwater of greater conductivity or at higher operating voltages and the load range is extended to practically no load.

The degree to which the spouted water prevents steam envelopes forming on the tips of the electrodes depends mainly on its cooling effect. A considerable portion of the energy dissipated at the electrode tips is used in raising the temperature of the feedwater to saturation temperature.

Fig. 4. Sectional view of a boiler showing a tip-shielded electrode with equipment for waterspout action.



To limit the voltage gradient and concentration of energy at the electrode tips as the water level falls to WL2, Fig. 4, a substantial volume of spouted water is required. With the use of multiple-jet waterspout nozzles, as shown in the plan view 7, the spouted water entrains a large portion of boiler water and the required volume of spouted water is obtained with only part of it being passed through pump 5.

Boiler Water Oscillation

It has been found experimentally that if water is spouted vertically from the bottom centre of a cylindrical vessel containing water to a depth equal to the diameter of the vessel, plus or minus about 25%, the body of water oscillates. An explanation of this phenomenon is that a mound of water is raised at the surface of the body of water, thus increasing the resistance to the flow of spouted water which therefore moves to one side of the mound. The mound follows and violent oscillation, with the spouted water tracing a conical pattern, rapidly develops. In this process the mound becomes a wave of surprising amplitude.

Unless means is used to prevent it, similar oscillation occurs when water is spouted upwards and around the tips of electrodes suspended at the centres of cylindrical neutral shells as shown in Fig. 4. This oscillation makes the spouted water ineffective as a means for preventing steam envelopes forming over the electrode tips and electrode corrosion with unstable boiler operation therefore results.

Tip-Shielded Electrodes[4]

The electrode 2, Fig. 4, has a tapered tip which is surrounded by a metal shield 8 at a distance to provide an annular space between tip and shield, the shield being mechanically and electrically connected to the tip.

Obviously, if all the spouted water were passed through the annular space between tip and shield boiler water oscillation would not develop. A large portion of the spouted water must, however, be displaced to the outsides of the tip shields where it is needed to prevent steam accumulation. It has been found in practice that oscillation does not occur unless the portion of spouted water passing through the annular space is reduced to less than 25% of the total volume. The equipment for waterspout action is designed to obtain about 50% dis-

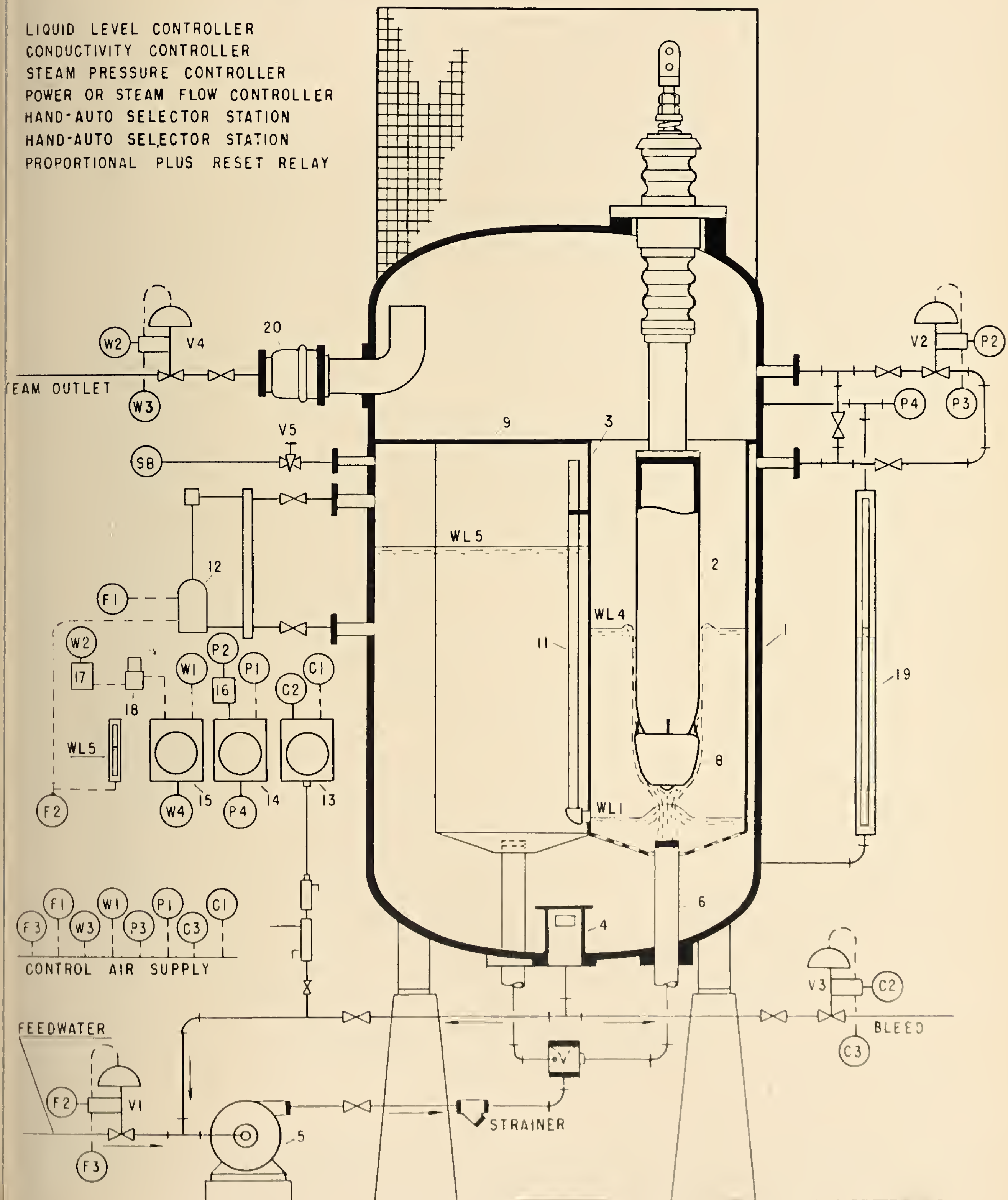
acement of spouted water to the iter sides of the tip shields. The use multiple-jet waterspout nozzles pro-des a sufficient volume of spouted iter for adequate coverage of the ectrode tip shields and for limit-g the voltage gradient as the water vel falls below the electrodes.

Although the current density and iergy concentration on the hemi-spherical tips of the electrodes are theoretically less when dimension M is equal to dimension A than they are for shorter M dimensions there are practical considerations. Tip shields with large M dimensions adversely affect the flow of spouted water and the release of steam from the water below them. For electrodes having a diameter greater than eight or nine inches the M dimension is therefore preferably less than the A dimension.

Automatic Electrode Boiler[5]

The automatic electrode boiler shown schematically in Fig. 5 is of a design based on the above definition of electrical characteristics.

Fig. 5 Sectional view of an automatic electrode boiler.



Construction

As shown in the sectional view of a typical boiler, a diaphragm plate 9 divides the boiler shell 1 into an upper steam-release compartment and a lower section. Three cylindrical tubes, part 3, arranged symmetrically at 120°, open into the diaphragm plate with which they are welded. The lower ends of these tubes are mechanically and electrically interconnected to form a grounded neutral for the electric circuit. These tubes, or ground shells, divide the lower section of the boiler into steam-generating compartments and a control compartment. Tip-shielded electrodes 2 are suspended at the centres of the tubes from terminal bushings. Equipment for waterspout action, substantially as described above, is provided. The boiler includes automatic control equipment, a suitable water column 19, steam dryer 20 and other stand ard accessories.

Automatic Control

The automatic control as applie to the Kaelin electric boiler has bee described in an earlier paper.[2] Although the same principles are ap plied in the present application, som alterations in control equipment hav been made.

The controllers shown schemati cally in Fig. 5 are of the air-operate

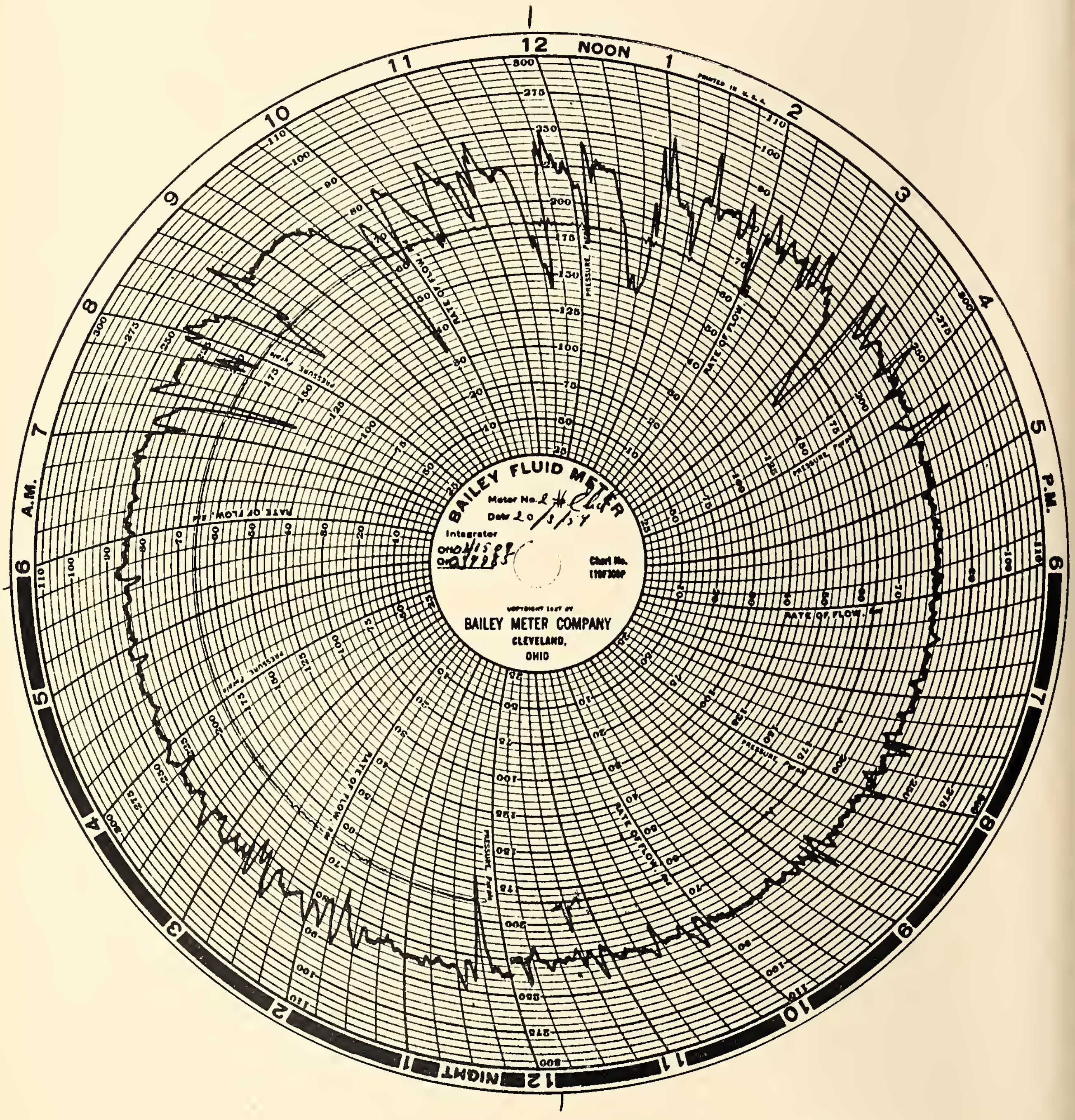


Fig. 7. Meter chart from a 30 MW Automatic Electrode Boiler supplying steam in a paper mill. The outer curve is steam flow. The inner curve shows the automatically controlled boiler steam pressure. The fluctuations in steam demand are caused by interruptions of steam flow to dryers occasioned by paper breaks. This chart illustrates an unusual degree of stability and precision in control performance.

ype which proves to be the most atisfactory for regulating large oilers.

eedwater Regulation

As shown in Fig. 5, feedwater is dmitted to the boiler under control f diaphragm valve V1, which in turn responsive to liquid level controller 2. Since all water entering the boiler n excess of that required for the oad is automatically transferred to he control compartment, the liquid evel controller functions to maintain n the control compartment the water evel WL5 at which stored water is rovided for raising the water level n the electrodes to increase load, nd space is provided for transfer of vater from the steam-generating ompartments to decrease the load. o use the space in the control compartment to the greatest advantage nd to stabilize feedwater regulation he controller is made of the proportional type and adjusted for a vide proportional band.

oiler Steam Pressure Control

The boiler steam pressure is naintained on the set point of controller 14 by controller action and by elf-regulation inherent in the design f the boiler.

The size of diaphragm valve V2 made such that when it is about half pen steam passes through it to the ontrol compartment at a rate equivalent to about 1% of the boiler capacity. Manual valve V5 controls the flow of eam SB bled off for control purposes. This steam may be used efficiently in a de-aerator, for preheating he feedwater supply, or in a low ressure heating system. Valve V5 is djusted so that when the controlled ressure is on the set point of controller 14 valve V2 floats in a halfpen position. If the controlled pressure deviates from the set point of nstrument 14, the opening of valve V2 is automatically changed to make he rate of steam flow into the control compartment more or less than he constant rate of bleed SB, thus ausing transfer of water between the team-generating and control compartments with a corresponding load hange in the direction required to eturn the controlled pressure to the et point. The controller is provided vith proportional-position action with djustable proportional band. If the oiler load is subject to suddenly pplied changes in excess of 25 per ent of the boiler capacity, reset action is desirable.

In addition to the controller ction, described above, there is selfegulation which is mainly responsible or the boiler load following the steam demand as closely as is indicated by the meter chart, Fig. 7. The difference between water levels WL4 and WL5 corresponds with a difference in steam pressures. Any change in the controlled boiler steam pressure therefore causes an immediate transfer of water in the direction to maintain the pressure constant. Large load changes, suddenly applied, are controlled by self-regulation with the proportional controller action functioning to make final adjustments of the controlled steam pressure.

Stand pipe 11 determines the low limit of water level WL1 and the minimum boiler load.

The meter chart, Fig. 7, shows that substantial load changes are made without it being apparent to an attendant, guided by a pressure gauge, that any action in this respect is required. Since the power input is made to follow closely the steam demand a high degree of control stability results.

Maximum Load Control

The maximum load taken by the boiler is determined by the operation of control valve V4, located in the boiler steam outlet and made responsive to power or steam flow controller 15. The signal W4 may be either from apparatus measuring (1) the total load on a system of which the boiler load is part, (2) the power taken by the boiler, or (3) the rate of steam flow from the boiler.

As the set point of instrument 15 is approached control valve V4 automatically decreases its opening, thus tending to cause the boiler steam pressure to rise and the boiler load to be reduced in response to the automatic steam pressure control.

For stable operation controller 15 is provided with proportional-position plus reset action.

While valve V4 is being throttled on load control, the boiler steam pressure remains constant but the system steam pressure falls unless it is maintained by associated boilers. In any case the electric boiler continues to function as a source of steam at constant pressure.

Boiler Water Conductivity Control

As boiler water is evaporated, the concentration of salts in solution and the resulting conductivity tend to increase and are maintained constant by the operation of the automatic conductivity control equipment. Controller 13 measures the conductivity of water taken from the boiler in response to which it regulates bleed valve V3. Boiler water bled off, or blown down, for conductivity control is replaced by comparatively pure feedwater, thus maintaining the desired boiler water conductivity at the set point of controller 13. The additional feedwater supplied for conductivity control increases the cooling effect of the spouted water, thus making it more effective as a means for preventing steam accumulation at the tips of the electrodes. By the use of proportional-position controller action the maximum sustained cooling effect is obtained.

Operating Efficiency

Neglecting radiation losses, the heat losses on which the operating efficiency depends are entirely in the blowdown water required for conductivity control. The rate of blowdown depends on the ratio of boiler water conductivity to feedwater conductivity and the proportion of bicarbonate hardness in the feedwater. As the temperature of the water is raised, calcium bicarbonate goes to the less soluble calcium carbonate with carbon dioxide being released

$$\underset{\text{calcium bicarbonate}}{Ca(HCO_3)_2} \rightarrow \underset{\text{calcium carbonate}}{CaCO_3} + \underset{\text{carbon dioxide}}{CO_2} + \underset{\text{water}}{H_2O}$$

The precipitation of calcium carbonate reduces the conductivity, thus decreasing the required rate of blowdown for this purpose.

Factors determining the required rate of blowdown for conductivity control may best be illustrated by a numerical example. Assume:

1. The conductivity of water to be directly proportional to its hardness in parts per million. (For relative values conductivity figures in micromho-cms may be substituted for hardness in ppm, or vice versa.)
2. Boiler operation at 200 p.s.i.g. with feedwater at a temperature of 200°F.
3. A feedwater composition of 80% condensate and 20% raw water.
4. An analysis of the raw water to show that it has a conductivity of 125 micromho-cms and that the proportion of bicarbonate hardness is such that the conductivity is likely to fall to 100 micromho-cms when the water is heated to saturation temperature.
5. A condensate conductivity of 10 micromho-cms.
6. Moisture in the steam as part of the blowdown and the portion of this moisture in the condensate to be accounted for by the condensate conductivity.
7. 20% blowdown.

Based on these assumptions. For every 10 lb. of water admitted to the boiler 8 lb. are evaporated and 2

lb. are bled off for conductivity control. The 10 lb. of feedwater is therefore composed of 6.4 lb. of condensate (80% of 8) and 3.6 lb. of raw water.

Conductivity of feedwater:

$$\begin{aligned} 6.4 \times 10 &= 64 \\ 3.6 \times 100 &= \underline{360} \\ &\quad 424/10 \\ &= 42.4 \text{ micromho-cms} \end{aligned}$$

To maintain a condition of equilibrium, soluble solids must be taken out of the boiler by the blowdown at the same rate as they are brought in by the feedwater. The conductivity of the boiler water must therefore be:

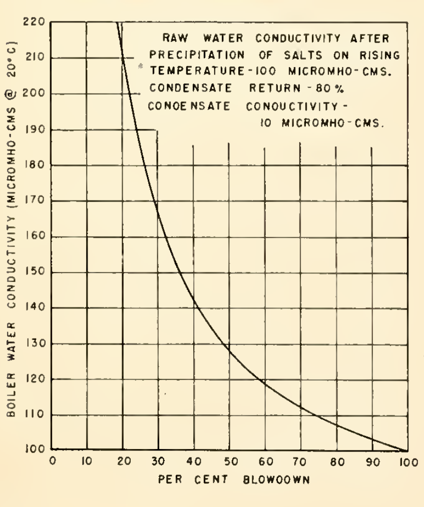
$$\frac{10 \times 42.4}{2} = 212 \text{ micromho-cms}$$

The points on the curve, Fig. 6, are determined by assuming various rates of blowdown. At 100% blowdown no steam or condensate is produced, but the feedwater is heated to saturation temperature, thus precipitating calcium bicarbonate as calcium carbonate and reducing the conductivity of the water from 125 to 100 micromho-cms.

Assuming that the boiler is designed for operating with a boiler water conductivity of 200 micromho-cms, the required rate of blowdown, as shown by Fig. 6, is 22%, at which for every 10 lb. of water admitted to the boiler 7.8 lb. are evaporated and 2.2 lb. are bled off.

If the boiler is operated at 200 p.s.i.g. and with a feedwater temperature of 200°F, 194 B.t.u. are required to heat a pound of water to saturation temperature and the latent heat of evaporation is 837 B.t.u/lb. The total heat supplied for each 10

Fig. 6. Relation between boiler water conductivity and rate of blowdown for given feedwater conditions.



lb. of water admitted to the boiler is

$$(10 \times 194) + (7.8 \times 837) = 8470 \text{ B.t.u.}$$

Assuming 3400 B.t.u./kwh.

$$\text{lb.-steam/kwh.} = \frac{3400 \times 7.8}{8470} = 3.13$$

If there were no blowdown, 10 lb. of steam would be produced by

$$(10 \times 194) + (10 \times 837) = 10{,}310 \text{ B.t.u.}$$

$$\text{lb.-steam/kwh.} = \frac{3400 \times 10}{10310} = 3.30$$

Operating efficiency

$$= \frac{3.13}{3.30} \times 100 = 95\%$$

The efficiency of electrode boilers usually falls between 93% and 99% depending on the conductivity of the raw water, the percentage of the steam returned to the boiler as condensate, boiler size, and operating voltage.

Operation at 13.2 kv.

The energy concentration at the electrodes

$$I_e^2 \cdot \rho_t \cdot S \propto E^2 \cdot \gamma_t \cdot \frac{1}{B} \text{ and}$$

and the B/A ratio as shown in Fig. 2. From this relation it is seen that the energy concentration is directly proportional to the square of the applied voltage E and inversely proportional to the size of the boiler.

When designing a boiler for operation at voltages lower than 13.2 kv. it is necessary to choose a B/A ratio such that the required range of load will be obtained with the desired range of water level on the electrodes. For 13.2 kv. operation the electrode diameter is made to obtain a B/A ratio of between 3/1 and 3.5/1 for minimum energy concentration. The limitation is then in the size of the boiler and the permissible conductivity of the boiler water.

The conductivity of natural water depends on the hardness in it which varies widely throughout the world, depending on the geological formations in contact with the water. For electrode boiler feedwater a distinction must be made between non-carbonate and bicarbonate hardness since the latter is reduced by heat. Water from a Laurentian or Rocky Mountain watershed is found to be suitable for 13.2 kv. boilers. The conductivity of the St. Lawrence River water is, however, too high.

Although the cost of water purification would tend to make the operation of electrode boilers uneconomical, if a boiler is operated in a closed system the cost of demineralizing a relatively small amount of water, required to replace leakage from the system, would be worth considering in comparison with the cost of a transformer installation for boiler operation at a lower voltage.

Modifications

The high voltage electrode boiler, above described, was developed primarily for the utilization of off-peak hydro-electric power to produce steam. Modifications of the design for various applications may, however, be made.

Low Capacity Boilers

Although air-operated controllers are used to advantage in the operation of large boilers, their cost is out of proportion to the cost of boilers in sizes up to 1000 kw. or larger. For relatively small boilers it has been found that more simple control equipment may be used with little loss in control performance. For example, a pressure-reducing valve reverse-connected and provided with a suitable spring for the desired proportional band may be substituted for control valve V2, Fig. 5; the feedwater regulation may be performed by a float switch arranged to control a feedwater pump; and load control may be satisfactorily performed by a suitable motor-operated valve made responsive to overload devices. Although these simple controls lack the adjustment and precision of air-operated controllers they prove to be adequate for applications of this class.

Acknowledgements

Credit is due to engineers of the Aluminum Company of Canada, the Iron Ore Company of Canada, and Price Brothers & Company for their co-operation in supplying operating experience leading to the perfection of design details. The author also wishes to acknowledge the assistance of his associates of Shawinigan Chemicals, Shawinigan Engineering Company, Shawinigan Water and Power Company and Dominion Engineering Company in the solution of various problems that have arisen in the course of this development.

References

1. See **Standard Handbook for Electrical Engineers,** Ninth Edition, Sec. 17-74.
2. "Improvements in Electrode Boilers" Engineering Journal, May, 1953, by M. Eaton, M.E.I.C.
3. Determined experimentally by Plant Research Laboratories, Shawinigan Chemicals Limited.
4. Patents pending.
5. Canadian patents 456,783—518,831—550,072 and the corresponding U.S. patents 2,453,211—2,611,852—2,729,730 have been assigned by the author to the Shawinigan Water and Power Company. A British patent 682,658 has been assigned by the author to Bastian and Allen of England. Manufacturing and selling rights in Canada are held by Dominion Engineering Company Limited, Montreal.

Discussion

GINEERING RESEARCH THE FISH AND WER PROBLEM

F. Muir, M.E.I.C.,
ad, Department of Civil Engineering,
iversity of British Columbia,
ncouver
gen Ruus
istant Professor, Civil Engineering
partment,
iversity of British Columbia

e Engineering Journal, October 1961
ge 98

scussion by
M. Shrum

The industrial and economic life of British lumbia is inextricably tied up with the lti-purpose use of our great rivers. The st important of these is the Fraser, which h its tributaries constitutes one of the rld's greatest spawning areas for an-romous fish. The Fraser also provides main centres of population in British lumbia with their greatest potential for xpensive hydro-electric power. There are er large river systems in British Columbia none so important to our fisheries and ne that offers such a potential for in-pensive energy. Furthermore, there is a d for flood control on the Fraser which uld be met by power dams and reservoirs. The authors have reviewed the present te of knowledge of the problem of getting ung and adult fish past power dams. ey also report on some original experi-ntal work by Professor Muir on the ects of pressure and cavitation on finger-gs passing through turbines.

Making use of the latest available in-rmation on fish ladders and other data ociated with the migration of young and ult fish the authors have put forward ecific proposals for a 700,000 h.p. 100 ft. m at Spuzzum. Their suggestion that this ucture should be designed so that further periments on the passage of fish could undertaken seems to be eminently sen-ble. They even suggest that if at any time e installation might seriously interfere with e passage of fish the turbines could be ut down and the power load taken up by her plants which at the fish migration nes usually have a surplus capacity.

All will endorse the authors' plea for further engineering research and development in this very important field. However, our present state of knowledge seems to have reached the point where one 100 ft. dam could be built on the Fraser without interference with fish migration. This dam could be used for research and experimentation and might pave the way for further developments which would ensure to the people of British Columbia both the preservation of their fish runs and the provision of cheap power. The expenditures entailed in such a research and development programme would be dwarfed by the benefits which would ensue. This paper makes a significant contribution to this vital problem.

Discussion by
G. B. Collins

Dr. Muir and Dr. Ruus have reviewed with care those aspects of recent fisheries-engineering research that appear to apply to the dam proposed near Spuzzum on the Fraser River. Although a few of the details of their review need closer scrutiny, their main argument that safe passage for fish could be provided at the 100 ft. high dam appears to be reasonable and supported by factual information. However, the authors admit that more research is necessary before the problems involved in safeguarding migrant fish are actually solved, and, toward that end a program of fisheries-engineering research is proposed to obtain the needed information.

One part of the proposed research involves model studies of the dam examining hydraulic features of spillway, turbines and fishways. Model studies of this nature are recognized as an important part of the planning of fish facilities for major dams on the Columbia River system. Model studies, however, do not contribute any new information on the requirements, abilities or behavior of the fish in question. For research on adult fish the authors suggest an auxiliary channel be placed adjacent to a fish ladder at the first dam constructed on the Fraser River for investigating types of fish ladders. Presumably, a program of fishway research similar to the one in progress at the Fisheries-Engineering Research Laboratory at Bonneville Dam[3] is envisaged. The authors point out that the results of this research would apply to the design of fishways at future dams. For research on downstream migrants, facilities are suggested for testing models of turbine runners to determine relationships between various turbine characteristics and fish mortality. Again, the authors acknowledge that results of the research will apply to future power plants. Thus, the fisheries-engineering research proposed in connection with the Spuzzum Dam would contribute little or nothing toward the design of fish passage facilities for what would be the first and possibly the critical dam on the Fraser River.

In the plan outlined by Dr. Muir and Dr. Ruus the research would begin, "if and when the first low head dam is constructed in the Fraser." An alternative is suggested and that is to do the necessary research before any dam is built. Collins[1] has pointed out that, "It is entirely possible and reasonable to measure the performance of fish in full scale fishway structures in the Fraser and in Alaskan rivers even before any dams are constructed. Solutions have been proposed for fish passage problems at high dams and at low dams. These should be tested before they are accepted as solutions and set in concrete. By acquiring a knowledge of fish reactions to specific fishway situations beforehand much of the guess and gamble of new fishway designs could be eliminated."

Arguing further on the same theme, Collins[2] (1959) states that "information on fish behavior required for designing new fishways is obtainable even before the dams are built. Just as test borings of rock formations determine in advance the feasibility of certain types of construction at specific dam sites—so can research on fish behavior determine in advance the feasibility of certain types of fish passage facilities at given locations with specific runs of fish."

It is important to recognize that possible solutions and promising lines of research toward solutions are not solutions in fact. In proposing power development in a river system such as the Fraser where fish passage problems are of a vastly different magnitude than in the Columbia River, a demonstrated ability to safeguard the passage of upstream and downstream migrants at a particular site might do much to overcome the objections of fishery organizations.

(Continued on next page)

References

1. Collins, Gerald B.
1958. **The measurement of performance of salmon in fishways.** In: H. R. MacMillan Lectures in Fisheries, a symposium held at the University of British Columbia, April 29 and 30, 1957. Edited by P. A. Larkin, Institute of Fisheries, University of British Columbia, Vancouver, B.C., pp. 85-91.
2. 1959. **Fish passage research for proposed dams.** Tenth Alaskan Science Conference, Juneau.
3. Collins, Gerald B. and Carl H. Elling. 1960. **Fishway research at the Fisheries-Engineering Research Laboratory.** U.S. Fish and Wildlife Circular 98.

Discussion by

G. H. Von Gunten

The authors have devoted a considerable portion of their paper to the subject of passage of downstream migrants through turbines with specific reference to several experiments conducted under the Corps of Engineers Fisheries Research Program. Additional tests through both model turbines at York, Pa., and prototype turbines at Cushman No. 2 have been made supplementing those referred to by the authors. Results are compatible with those previously observed and are summarized in the following discussions.

In 1958, a review was made of known test data and factual evidence of injury to fingerlings in passing through turbines and by exposure to high hydrostatic pressures. This review did not disclose any factual evidence which specifically indicated injuries were related to high positive hydrostatic heads. In several instances, such as the Elwha tests, mortality was observed where one of the exposure conditions was a hydrostatic head exceeding 100 ft. However, negative pressures, hydraulic turbulence, mechanical injury, and other factors could well have been the cause of death. With this in mind, and in view of the apparent reduction in survival at Big Cliff under inefficient part-load operation, it was evident that an analysis of the significance of negative pressures in turbine passageways would be of value. After considerable investigation, it was deemed likely that survival as related to the extent of negative draft tube pressures or cavitation could be explored by passing small fish through 12 in. diameter model turbine runners. The first experiments conducted at the Allis-Chalmers laboratory at York, Pa., under operating heads up to 45 ft., proved conclusively that turbine runner setting in relationship to tailwater was a major factor in survival. Varying directly with the speed, mechanical injuries killed from 5 to 50% of the fish under high tailwater conditions. The kill could be increased to nearly 100% by raising the runner setting. This finding indicated that negative pressures and/or cavitating conditions, not high positive hydrostatic heads, caused injury. Consequently, it was decided to conduct tests at a high head prototype. City of Tacoma, Cushman No. 2 plant, with a power head of 470 ft., appeared the most favorable to achieve a high recovery of test specimens, a significant survival, and the possibility of demonstrating a change in survival associated with a change in tailwater level. Survival of about 75% was achieved under favorable turbine operating conditions. Definite changes in survival were also noted as related to tailwater level and turbine efficiency associated with both part-load and overload operating conditions.

Although the Cushman No. 2 prototype tests were very promising toward successful passage at high head plants, approximately 60% of the injuries experienced were of mechanical nature. In view of this, additional tests were conducted at York which involved the following physical variables: (a) number of runner blades; (b) number of wicket gates; (c) clearance between wicket gates and runner blades; and (d) size of test fish.

A significant change in survival was demonstrated to be associated with each variable. A relatively small change in clearance (3/8 in. or one-fifth the length of test fish) between the intake edge of blades and wicket gates increased survival from 73% to 83% at 537 r.p.m., representing a 37% reduction in kill. In view of the results, additional tests were performed at Cushman No. 2 using graded fish 3 in. and 6 in. in length to investigate the relationship of fish size to survival. A summary of test results follows.

Cushman No. 2 Tests—1961

Wicket Gate Position	Percent Total Survival* 3 in. Silver Salmon	6 in. Steelhead Trout
.40	34.5	
.50	50.9	51.9
.60	59.5	38.6
.68	60.5	42.3
.76	72.0	50.0
.84	68.4	33.8
.99	64.9	

*Average of all tests

Highest survival of one test with silver salmon was 76% at .76 gate.

Lowest survival of one test with silver salmon was 32% at .40 gate.

Since the recovery of 6 in. steelhead was only 83%, compared with 96% for three-inch silvers and 100% for planted dead fish, the survival was probably appreciably greater than the indicated results.

It appears from these results that the relationship of turbine speed to the approximate wicket gate blade clearance at Cushman No. 2 is well beyond critical for the 6 in. fish but approaches being adequate for the 3 in. fish, and that relatively small increases in clearances would eliminate any significant mechanical injury.

None of the five test programs have provided evidence that the magnitude of hydrostatic heads is a significant factor to the survival of fish in passing through turbines. The tests, however, conclusively demonstrate that design features and operational characteristics are important to survival. These findings give much promise to safe passage through properly designed high head turbines. They also demonstrate that turbine design and operational characteristics even for low head turbines must be favorable to assure safe passage.

Discussion by

Frederick K. Cramer

The techniques and procedures used in the tests conducted by the U.S. Army Corps of Engineers on fish passage through turbines have aroused considerable interest. A brief review of techniques and procedures used in the Cushman tests will supplement Mr. Von Gunten's discussion of the results obtained.

The basic problem involved introducing test fish positively and safely into the penstock and safely recovering a large percentage of them after they had passed through the turbine into the tailrace. Introduction into the penstock was accomplished by use of a fish lock, and capture of both test and control fish was made by use of a large nylon net that strained the entire turbine discharge of 800 c.f.s. and led the fish to the live box attached to the distal end of the net.

The fish lock was essentially a 12 in. diameter pipe, 4 ft. long, and fitted with valves at each end. At the discharge end of the lock, a 4 in. diameter pipe led the fish into the penstock. The end of this pipe was tapered and faced downstream so as to direct fish into the flow. Compressed air gently moved the fish and water out of the lock into the penstock.

The large net was 8[illegible] long, 29 by 23 ft. at the forward opening, tapered to a 3 x 3 ft. opening at the distal end and was, in reality, three [illegible] fitted and attached together. The front end of the net was attached to a net frame, the frame being set on the bottom of the tailrace and flush against the pier noses. The net frame and net weighed approximately five tons and the entire assembly was lifted and placed into position by a crane.

The scoop trap at the end of the net was 9 ft. long and 5 ft. wide, containing an inclined plane of eight-mesh, 27 gage screen leading from the forward opening to the live box, a sanctuary at the rear of the trap. A baffle plate, hinged at the downstream end of the inclined plane and extending into the live box created an excellent resting area in the live box. The entire trap was trimmed and set in the best fishing position by means of compartmentized floats.

Tattooed test and control fish were transported to the plant for each test, with the test fish released through the lock at the upper end of the penstock and the control fish released through a standard planting hose from the powerhouse tailrace deck into the net. After removal from the live box, all fish, test and control, were placed into a tank truck and returned to the hatchery for holding to record delayed mortalities and type and extent of injuries occurring in dead and injured fish.

In these tests at Cushman No. 2 hydroelectric plant, fish were obtained from Washington State Department of Game and U.S. Fish and Wildlife Service; certain services, including tattooing and fish hauling, were obtained from Washington State Department of Fisheries; and pathological examinations were performed by the U.S. Fish and Wildlife Service.

In the 1961 tests at Cushman, recovery of test silver salmon was 96% of those planted, recovery of control fish was 84%, recovery of all fish was 92%. Known dead fish were planted through the penstock on four different occasions. All of these were recovered in the live box. This would strongly indicate that the fish not captured were alive and probably remained in the tailrace or draft tube area. A few may have managed to swim upstream in the penstock from the lock to the surge tank, especially the stronger swimmers during tests on reduced power loadings. Inspection of the inside of the net by scuba divers midway in the test program revealed no pockets of dead fish.

No tests had to be repeated because of malfunctions in equipment or inconsistencies in procedure. Individual test results for any particular wicket gate position tested were consistent, and maximum variation for any individual test at the same gate position, using silver salmon, was about 3% from the mean for that particular series.

Experience gained in development of procedures and equipment used in the tests utilizing model turbines was of great help in development of similar techniques that could be applied to large prototype conditions.

Cost of the 1960 tests was approximately $35,000, including all operational costs plus the design and manufacture of equipment. The 1961 tests cost approximately one-half of this amount due to reduction in equipment cost.

(Continued on page 67)

Discussic

(Continue. from page 64)

uthors Reply

We wish to ress appreciation to those ho hav ed to the discussion of ur pap .

We are, o , gratified to have our ews corrobora by Dr. Shrum who has icceeded admirably in summarizing the ajor aspects of the problem of multi-urpose development of the rivers of B.C.

Dr. Collins says that "the fisheries-engi-eering research proposed in connection ith the Spuzzum dam would contribute ttle or nothing toward the design of fish-assage facilities for what would be the rst and possibly the critical dam on the raser River."

We believe that the first dam at Spuzzum ould not be the critical one on the Fraser. onstruction of the dam would result in iundation of several rapids in the reser-oir in which the minimum velocity during ie period of peak migration of adult fish ould be about ½ f.p.s. The fish ladders the dam would replace the Hell's Gate shway.

Tests at Columbia River dams indicate iat attraction of fish to the ladders is rongly dependent on the amount of at-action water supplied. On the Fraser at puzzum during the migration period of dult fish, large quantities of surplus water om the reservoir are available for dis-ibution over the entire width of the river nd at the fishway entrances.

The critical question to be answered is How would the time of passage of adult sh through the Spuzzum reservoir com-are with the time of passage through the ell's Gate, Scuzzy, and Black Canyon apids?" We believe that the Spuzzum dam ould result in a reduction in delay in iigration of adult fish through an 11 mile ngth of the river.

Dr. Collins has made the interesting pro-osal that fishways be built and that the erformance of fish be measured in them rior to construction of dams on the Fraser. his idea should be given careful study.

Hydraulic model studies of the ladders roposed by Dr. Collins would be invalu-ble in predetermining the water velocities the full-scale ladders as well as those the river at all stages before, during and fter construction of dams. The risk of iterference with fish migration, resulting rom dam construction, would be mini-iized by such studies of hydraulic flow atterns.

The research projects on passage of oung fish through the model turbines at he Allis-Chalmers Co. laboratory and hrough the full-size turbines at the Cush-ian plant are among the most important rojects arising from the Corps of Engi-ieers' Fisheries-Engineering Research Pro-ram. We wish to express appreciation to Ir. Von Gunten and Mr. Cramer for their iscussion which brings information on this esearch up to date.

The recent full-scale tests at the Cush-ian plant give further confirmation of aboratory findings showing that neither iigh hydrostatic heads nor the rate of re-luction in pressure are significant factors n causing mortality among fish passing hrough turbines.

These tests also showed that an improve-nent in survival rates can be achieved by nodifications in design, setting, and oper-iting conditions of turbines. We believe hat in low head plants, with properly de-igned turbines operating under best hy-lraulic conditions, a survival rate close to 100% could be achieved.

OUTLO K ON THE RELAT NSHIP BETWEEN LOAD-F EQUENCY CONTROL AND TURBINE GOVERNORS ON INTERCONNECTED POWER SYSTEMS

Luke O. Long, M.E.I.C.,
Special Assignment Engineer,
The Shawinigan Engineering Company Limited,
Montreal.

The Engineering Journal, December 1962 page 42

Discussion by Nathan Cohn

I find myself in agreement with the basic conclusions outlined by Mr. Long, namely, that members of a power interconnection should adopt a progressive and co-operative attitude toward the problems of regulation, should embrace advances in regulating concepts and equipment, and should seek to dispatch and regulate their respective areas so that overall system operation achieves optimum reliability and economy for customers and utilities alike.

Co-ordination of Controls for Non-Interacting Operation

Throughout Mr. Long's paper there is emphasis, which I think very appropriate, on the need for co-ordinating the many control entities that can simultaneously share in the solution of the overall regulating problem.

On a typical multiple-area[1] interconnection, these control entities would include many net interchange tie-line bias controllers, a number of supplementary allocation controls for the regulating units, and the governors themselves on the large number of turbine-generators that make up the interconnection. All of these many control entities are generally able to respond concurrently to their respective input signals, each seeking to do its part of the overall regulating need. Manifestly, it is important that this considerable number of concurrently operating control devices—there may be as many as several hundred of them on a large interconnection—perform co-operatively with respect to one another, with each preferably doing only that which it is supposed to do, and refraining from doing that which it is not supposed to do. When that is not the case, when regulators take action which they are not supposed to take, they only induce a cycle of further regulating steps to undo the improper action that has been taken, resulting in unnecessary regulation for the system as a whole.

In brief, best overall regulation is obtained when all of the many control entities, at the area level, the station level, and the unit level, are co-ordinated, with each acting in accordance with predetermined operating criteria to correct errors, and not to create them. Optimum regulation is that minimum regulation which will fulfill a predetermined criteria established for the system as a whole, for each area of the interconnection, and for each station and generating unit. Mr. Long very properly emphasizes the importance of control concepts and executions which will achieve the necessary regulation with minimum interaction.

Aspects of Control Execution

In discussing how best to achieve such non-interacting co-ordination, Mr. Long analyzes a number of important factors, such as steady state versus transient conditions, slow versus fast responses, proportional versus integral actions, and sustained versus fringe controls. Certainly each of these matters must be carefully considered for each control installation, though it is quite possible that different combinations of arrangements might be selected to meet the conditions and requirements of a given installation.

It might be helpful to identify three separate steps that can prevail in the generation control process, examining them briefly in terms of some of the factors which Mr. Long discusses.

The three steps to which I refer are:

(1) Computing the generation level desired at any given time for the area, or for the station, or for the unit under consideration; and developing an error signal which represents the difference between this desired generation and the actual prevailing generation.

(2) Developing a control signal from this error signal.

(3) Applying the control signal to the controlled energy source.

The first step should certainly be carried out as rapidly as possible. Where it involves a number of variables, as in a net interchange tie-line bias measurement, every effort should be made to achieve simultaneity of measurement, so that the resultant of the measurement is truly representative of the prevailing generation need. Further, I believe this step need in general concern itself only with the steady state need, the dynamic response needs being taken care of in the second and third steps. Also, this first step can produce, as for a station or a generating unit, a desired generation level which represents either (a) the level needed for economy dispatch, i.e. a sustained assignment, (b) the level needed for participation in area regulation, i.e. an area assist or fringe assignment, or (c) combinations of the two.

It should be noted that the terms "sustained" and "fringe" as used here do not define the way in which control is to be executed, but rather they define the nature of the desired generation assignment resulting from a change in customer load.

In general, most systems operators would be happy to have each increment of customer load change taken once by that source or those sources which are to retain the change for its full duration. But prevailing economy dispatch allocations sometimes involve units which cannot, for one reason or another, respond as rapidly as may be needed to keep area requirement at a minimum. In such cases, the "sustained" economy dispatch is supplemented by a temporary "area assist" or "fringe" assignment, which lasts until the "sustained" assignment has been fully absorbed by the unit or units to which it has been allocated.

I realize that I have here introduced the matter of economy dispatch, even though this was not a part of Mr. Long's presentation. However, economy dispatch and area regulation are very closely related, particularly when one applies automatic control to most or all of the generating sources of an area. Here one very reasonably seeks to have the generation responses that take place as a result of economy dispatch allocations simultaneously fulfill the needs of area regulation, thereby fulfilling as nearly as one can the criterion that each increment of load change be taken only once—if possible—within the area.

In any event, with the definition of "sustained" and "fringe" assignments as above noted, it is interesting to observe that the control signals developed in the second

(Continued on next page)

• Discussion

step may be of the integral type or the proportional type, or combinations of them with a derivative response added, all selected with due consideration to the dynamic response characteristics of the regulated variable and the intermediate control means. Where high speed responses are desired, proportional action would certainly be included along with the integral action, but this might be done to achieve either a "sustained" assignment or a "fringe" assignment, or both.

Also, the use of a high speed response in the second and third steps, as on a station or unit economy dispatch assignment, is best carried out when the first step involves a non-interacting computation of the desired generation for each participating source. With such a computation, the desired generation level computed for each source for a given area load is independent of the rate at which other sources are responding to their assignments. In this way, control action for each source, as carried out in the second and third steps, can be matched to the responsiveness of that source, without influencing the generation assignments computed for other sources in the first step.

This is very helpful in achieving the desired co-ordination of regulators operating in parallel.

Advantages of Electric-Hydraulic Governors

A principal point in Mr. Long's paper—perhaps the major one—is his emphasis on the turbine governor as the cornerstone of power regulation, and his advocacy of the electro-hydraulic governor as an important advance in achieving better system regulation. I would expect that Mr. Long would find considerable agreement with these views. Certainly every step taken to improve basic governing on a system makes the task of supplementary regulators correspondingly easier. The introduction of electric-hydraulic governors would appear to hold promise from the viewpoints of both improved basic governing and better co-ordination with supplementary controls.

For example, when mechanical governors and supplementary regulators are used in concert, there exists two possible sources of control action on the turbine. It is important that the supplementary regulator have sufficient intelligence to co-ordinate its actions with the responses of the speed governor. In practice, bearing in mind the possible variations in mechanical governor responses, its deadband, etc., this is not always easy to do. With electric governors, having definite pre-set response characteristics, it should be possible to achieve the co-ordination more readily, and with greater assurance of a co-ordinated match between the two.

Indeed, if electrical governing is carried on to its logical end, it would seem that in time there no longer need be two sources of control action on the turbine, with the attendant need for co-ordination between them. It would appear that all control effects could be combined into a single regulator.

These control effects could include (a) frequency, (b) unit output, (c) an economy dispatch signal which would establish the desired level of sustained generation for the unit to carry its share of the total generation needed at that time from the area and (d) an area assist signal, proportionate to area requirement, representing the "initial" or "fringe" response desired from the unit over and above its sustained assignment for economy dispatch. With the electric governor acting to reduce the algebraic sum of these four signals to zero, the single regulator on the turbine, acting in effect as an "area governor" would cause the unit to (1) do its share in frequency regulation, (2) do its assigned share of area assist and (3) achieve its assigned economy dispatch generation level when frequency and area assist have been returned to normal.

Also, the assignment of a specific frequency factor or unit frequency bias to the electric governor would facilitate determining the appropriate bias setting for the area net interchange tie-line bias regulator. This setting would then become the aggregate of the unit bias settings for all the governors of the area plus an additional factor to correspond to the frequency coefficient of the connected load of the area.

Reference

1. Nathan Cohn, **"Methods of Controlling Generation on Interconnected Power Systems"**, A.I.E.E. Paper 60-846.

Discussion by
N. P. Percival

An accurate descriptive paper from an independent source has long been overdue and we welcome Mr. Long's paper as a step in the right direction, and trust it is the first step towards standardizing the terminology that had grown up around load frequency control techniques.

We endorse the comments concerning the negative thinking attitudes with respect to the choice of slow response components for the telemeter and control aspect of load frequency systems. In particular it cannot be too strongly emphasized that the response of a group of interconnected systems is only as good as the worst member of the group. In considering the section referring to the suggestions for improving interconnected systems regulation, care has to be taken in considering the word stability: two sources of instability are possible, first, the machine and line instability as understood by the power engineer and determined by the machine and transmission constants; and second, the control loop stability as understood by the servo or control systems engineer and dependent on the gains and time constant of the control loop.

A stability study of the fringe control loop shows that the gain at high frequencies must be reduced for stability reasons and this can be effected by any one of several methods normally available to closed loop analyses:

(a) The gain may be adjusted until stability is obtained.

(b) The rate of change of power may be reduced by choosing the gate dashpot parameters to give the fastest possible response compatible with stability.

(c) The tie-line error signal, transmitted by the control centre to the controlled station, may be processed by passive electrical networks before transmission, i.e., phase lead or lag networks in the error path.

It has been our experience that, in attempting to obtain faster response on fringe control, discussion has generally centred round the removal of all the rate of change of gate feedback and stability obtained by gain adjustment of the telemeter channel or governor.

Methods (b) and (c) have the advantage that higher loop gains may be used to enable the fringe control to pick up a reasonable amount of the load change, the fraction being picked up is $\frac{G}{1+G}$ where G is the loop gain. It is considered that the fringe control should pick up about 80% of the load change, hence demanding a loop gain of 4. Whereas in practice it may be difficult to stabilise a loop gain of 1 with method (a).

A particular test showed that when a loop gain of 2.5 is used, the control was unstable with gate damping parameters of 25% strength and 0.06 seconds time constant, but stable when the time constant was increased to 0.2 seconds; it was highly unstable with a loop gain of 1 when all the gate feedback had been removed.

For high performance fringe operation care must be taken in choosing a station or stations with a small pipe-line effect and having an overall regulating capacity of about ±15% of the tie-line capacity.

The tendency to regard the accelerometer stabilised governor as the ideal control, because there is no necessity for a damping parameter reduction (dashpot by-pass) when coupled to the system must be tempered by the following considerations.

While an accelerometer signal alone may be sufficient to stabilize a Francis machine governor when operating at the low gate condition and not synchronized to the system, our experience, on control system analysis of all types, shows that one cannot stabilize a hydro governor at full gate local load with an accelerometer signal alone, except by a large reduction in the governor sensitivity: thus particular consideration must be given to those sites that may become disconnected from the system and left with a large local load. This point is admirably demonstrated in a paper by H. Schiott (Society of Instrument Technology, Vol. 12 No. 1 1960.), where he advocates the combination of gate dashpot effect and accelerometer effect to obtain improved response over a gate dashpot alone when operating on an isolated load.

It is not possible to generalize and say whether Kaplan or Propeller Machines with large no-load gate values would be stable at speed no-load with a pure accelerometer stabilizing signal. It would depend entirely on the magnitude of the pipe-line effect.

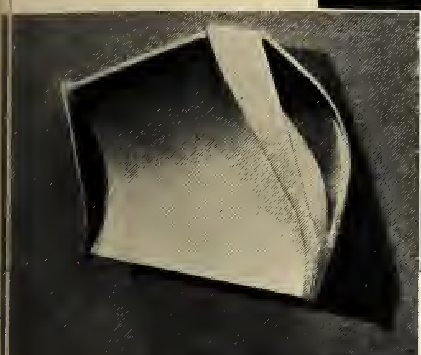
Discussion by
L. M. Hovey

This paper provides an excellent description of the role of hydraulic turbine governors in relation to the load-frequency control aspects of an interconnected power system. It also gives a very lucid explanation as to how the various components of a governor interact to provide speed control of a hydro unit and what means are utilized to stabilize the machine. However, there are several points in the paper on which the writer would like to comment:

For example, on Page 3, second paragraph, it is noted that "for steady state stabilization where the load and frequency changes are slow or gradual, the regulation afforded by self-regulation and permanent speed droop is usually adequate". It is the writer's experience that extreme caution should be used in adopting the above philosophy due to the fact that the self-regulation factor, usually encountered in a

(Continued on page 102)

Made to deflect tornadoes at white heat...



asting of nozzle guide vane
r turbo-jet engine

Radiograph shows casting sound and up to its job

lozzle guide vanes in turbo-et engines must withstand iery blasts — dependably. ustenal Company, division of Howe Sound Company, hecks the soundness of each ast vane with radiography

Cobalt base or nickel base high-emperature alloys are required in rder to withstand these terrific tem-eratures. Investment castings are pecified because of the alloys that nust be used and because the vanes vould be almost impossible to forge, nachine, or otherwise fabricate, at he cost level of investment castings.

Austenal Company, division of Howe Sound Company, casts these blades by the "lost wax" method. Each one is then radiographed to make sure that no hidden flaw lurks within that could cause failure.

Makers of quality castings, small and large, find radiography invaluable in making sure that only high-quality work is delivered. It is a way reputations are built and new business won.

Radiography can work for you, too. To find out how, talk it over with a Kodak x-ray dealer or write to us.

New . . . Ready Pack in ROLLS and SHEETS.
Kodak Industrial X-Ray Film, Types AA and M, in 200-ft. rolls (16mm, 35mm, 70mm) and sheets (8 x 10, 10 x 12, 11 x 14, 14 x 17).

- No darkroom loading—film sealed in a light-tight envelope.
- Just place Ready Pack in position and expose.
- Film protected from dust, dirt, light and moisture.
- In the darkroom—remove film from envelope and process.

CANADIAN KODAK CO., LIMITED
Toronto 15, Ontario

Kodak
TRADE MARK

Month to Month

Meeting of Council

The Council of the Institute met in Montreal, Saturday, February 3, 1962. President Ballard was Chairman of the meeting which was attended by 28 Councillors. Following are highlights of the meeting.

1962 Budget

The Institute's 1962 budget was considered and approved. During discussion it was clearly indicated that the E.I.C. publications program is self supporting, but that the membership account again will suffer a deficit of about $50 thousand. Council again noted the obvious fact that the average fee of just more than $10 per member, excluding students, is insufficient to pay for services expected by the members and that increased fee revenue is essential.

The following motion was passed:

1. Whereas the E.I.C. has experienced operating deficitis of $32,008 in 1958, $5,775 in 1959, $55,772 in 1960 and anticipates a deficit of about $60,000 in 1961, and

2. Whereas this situation has developed in the membership area only — contributions received vs. expenditures — the Journal operation during these years having been self supporting, while also contributing to the publication off Transactions, Careers, etc., and generating a substantial contribution to the general expenses, it being in the order of $50,000 per year, and

3. Whereas fees were reduced by $4 for all corporate members in 1960, when Council decided to increase the circulation of the Journal to meet competition - this sum of $4 being the subscription to the Journal as defined in the By-Laws, and

4. Whereas this reduction in membership fees represents a shrinking of the revenue by approximately $75,000 annually in 1961, and

5. Whereas the costs of doing business have risen generally, the last fee increase was in January, 1954, and

6. Whereas the corporate membership has grown by 20% from 14,335 in 1958 to 17,260 in 1961, and the student membership by 27.5%, having increased from 4,150 to 5,279 during the same period, and

7. Whereas requirements for existing and additional services have been and are being made by this increased membership, and

8. Whereas the depletion of the Institute reserves has taken place during the same period, either through the sale of securities or the writing off of previously established reserves at an alarming rate which cannot be sustained, and

9. Whereas this Council wishes to affirm its determination to continue to provide these services and to improve them.

Therefore, be it resolved:

1. That Council make it be known to the membership that it is in favor of a general increase in fees, as shown in the following schedule, and

All Branch Residents		Branch Non-Residents and Non-Residents
$24	Fellows	$22
24	Members	22
14	Assoc. Members	12
3	Students	3
25	Affiliates	23

2. That its decision be made known to the membership in the Engineering Journal, and

3. That it advises the membership of its intention to present a notice of motion for the above increase in fees at the 1962 Annual General Meeting.

Furthermore, Council expects each Councillor and Branch Chairman to collaborate in influencing members in their localities to vote in favor of this change in By-Law. Supporting financial information will be provided these officers in due time.

Vice-President G. N. Martin, Chairman of the Finance Committee, reported on special studies made by a Finance Committee sub-committee regarding the best method of handling the data processing problems associated with the Membership, Records, publications distribution and fee accounting.

The Institute's rapid growth in recent years and the wide circulation of the Engineering Journal constitute a load beyond the capacity of the existing equipment. Council approved immediate action to remedy the situation by the installation of appropriate systems and equipment.

Confederation

Council spent considerable time in consideration of the results of studies of the report of the Engineers Confederation Commission. Realizing that Branches have expressed the desire to learn of Council's view regarding the Report, and considering that sufficient study and discussion has taken place to enable Council to formulate an expression of opinion, a statement was prepared for distribution to Branch Chairmen.

Library

Extremely careful consideration was given to the future of the Institute Library, and to whether it would be in the interests of the membership to proceed with the suggestion that it be disbanded and that members use the National Research Council and other libraries. Opinions from Councillors and Branches in many parts of Canada were presented both verbally and in writing. After discussion, Council concluded that since these other library services now are available to the members, and that despite this the services rendered by the E.I.C. Library have increased greatly, to discontinue the Library would actually mean depriving the members of an extremely useful service. Council concluded that the Library should continue in existence, noting at the same time that it is operating at a surprisingly low cost and with commendable efficiency.

Striking Committee..

Past-President Dr. George McKinstry Dick was named Chairman of the Striking Committee which is responsible for nominating Chairmen of Committees for the coming year to Council. It was agreed that these nominations should be received by Council at its April meeting, rather than waiting until mid-year. This will permit continuity of Council activity throughout the year.

Future of the E.I.C.

Council then devoted its attention to a serious look at the future of the Engineering Institute of Canada. It recommended that the specific aims set forth in the E.I.C. Charter and By-Laws, implemented with care and diligence, will lead to a bright future, far surpassing the achievements of the past. Council re-affirmed its determination to recognize the following role of the Institute:

1. The continuation of its role as a national, voluntary, professional and learned society in the field of engineering and the enhancement of this role in all feasible respects.

2. Serving its membership in every manner consistent with improving the

ability of its members to most adequately serve the nation as professional engineers of the highest calibre.

3. Serving the nation and the membership by the publication of the highest-quality papers making available the development of new ideas, processes, construction and development in the field of engineering in Canada.

4. The encouragement of its Branches to fulfill their role, in their Branch areas, as organizational units of the Institute, devoted to the pursuance at all times of the same objectives and aims as the Institute.

5. Co-operation with sister institutions or societies for the advancement of mutual interests, on a basis of reciprocal contribution to the objectives of the Institute.

Technical Activities

Council approved the formation of a Communications, Electronics and Automation Engineering Division of the Committee on Technical Operations, and approved Professor G. Glinski of the University of Ottawa as Chairman.

Encouraging progress was reported regarding the technical program of the 1962 Annual General Meeting. Approval was given to a substantial number of technical conferences to be held in ensuing months.

Publications

R. A. Phillips, Chairman of the Publications Committee, reported that the Committee has been concerning itself with the best method of publishing Transactions, and a serious study of the non-technical content of the Engineering Journal. Engineering Careers in Canada will be published again in 1962. The Committee is preparing a guide to authors of technical papers for E.I.C. publications.

Emergency Measures Organization

Council received an invitation from the Emergency Measures Organization of the Privy Council Office in Ottawa to send 15 delegates to a special orientation course for engineers and architects to be held at the Canadian Civil Defence College at Arnprior, Ont., from April 30 until May 4, 1962. The invitation was accepted and the General Secretary was instructed to request names of candidates from all Branches to ensure representation from all provinces.

E.I.C. ELECTIONS AND TRANSFERS

A number of applications were presented for consideration and on the recommendation of the Admission Committee, the following elections and transfers were effected at a meeting of council on February 3, 1962.

Applications through Associations

By virtue of the co-operative agreements between the Institute and the Associations the following elections and transfers became effective February 3, 1962.

SASKATCHEWAN

Members: F. Casper, D. W. B. Wright, R. D. Wright.

Associate Member to Member: R. J. Baron, J. R. McClement.

NOVA SCOTIA

Associate Member to Member: F. D. Gallagher, A. E. More.

REPORT OF THE ADMISSIONS COMMITTEE

Members: W. H. Baker, Niagara Falls; B. S. Bhogal, Toronto; D. D. Campbell, Vancouver; A. Coulson, Ottawa; A. W. Dales, Winnipeg; W. R. Drynan, Waterloo, Ont.; R. F. Froats, Windsor, Ont.; T. B. Goodfellow, Montreal; G. Hall, Winnipeg; G. B. Jost, Montreal; J. B. Kemp, Port Credit; L. T. Kulynch, Richmond Hill; R. Leitass, Montreal; E. W. Mitchell, Lively; T. D. Northwood, Ottawa; W. A. Mehler, Vancouver; T. M. Noskiewicz, Toronto; H. J. O'Beirne, Sept Iles; J. L. Peterson, Port Cartier; D. Petrie, Toronto; L. L. Schaut, Ottawa; W. J. Trembath, Montreal.

For Admission as Associate Member: W. E. Allen, Vancouver; T. W. Szalay, Windsor, Ont.

STUDENTS ADMITTED

University of Manitoba: W. Almdal, C. K. Andres, J. C. L. Arthur, B. S. Avis, S. Barber, B. W. Belecki, J. P. A. Bertens, A. W. Bischoff, I. D. Bonnor, L. M. Borowski, R. J. Brown, B. M. Callum, D. B. Cameron, R. A. Cantelon, L. Q. Chow, F. J. Clancy, F. G. Clarke, D. H. Cleve, G. D. Clifford, W. G. Cook, K. J. Couprie, G. F. Cummer, A. J. Currie, J. C. Dale, M. A. G. Danielson, D. R. Downey, T. N. Dudar, D. B. Duncan, E. W. Dutchar, D. L. Eckhart, D. R. Ellchuk, G. B. Ennis, B. A. Fourschou, J. E. Forrest, L. A. Foster, J. F. Francis, W. R. Fumerton, J. D. Gill, M. N. Goldberg, A. D. Gould, E. V. Graham, G. A. Greb, A. Gritzinger, M. S. Harrison, M. R. Hastings, K. R. Hauard, D. C. Hicks, R. L. Holmes, C. H. Howard, A. S. Hutchings, L. W. Ife, D. P. Jardine, W. B. Jennings, W. A. Johnson, N. W. Kalinowich, R. J. Kavanagh, A. A. Keating, M. L. Kenny, K. Kiazyk, W. A. Kirkpatrick, M. Kishta, E. A. E. Klemm, P. J. Knight, W. B. Kochuk, G. P. Kolodinsky, L. G. Krause, J. Kukurudziak, E. J. Lea, E. A. Lipinski, T. Loewen, J. R. MacDonald, F. B. MacIntosh, J. D. Martin, A. Martynowicz, W. T. Matthews, J. A. McDermid, W. M. A. McDonald, W. G. McGarva, R. G. McIntyre, W. J. Melko, G. E. Metcalfe, S. Mindess, D. V. Mosbeck, H. T. Motyka, A. J. Muir, R. W. Newbury, J. M. Newhouse, T. I. Norman, E. V. Oliver, D. Pfaff, D. G. Pincock, R. A. Poltroneth, E. L. Proeyshyn, D. G. Ramsey, B. C. Rattray, E. J. Rewucki, J. C. S. Richl, W. J. Ripat, G. R. Ritchie, W. G. Rooke, R. A. Saunders, H. G. Schmidt, J. J. Schreuder, E. Schroeder, J. Schwahn, G. A. Schwartz, T. R. Scott, J. P. Seddon, K. W. R. Serne, D. A. Sernyk, E. Shwedyk, A. W. Side, G. S. Simpson, G. A. Smith, J. G. Stebbing, R. L. Steele, R. R. Steffan, D. G. Stephens, M. H. Stoller, B. D. Stone, W. Tibelius, J. N. Tompkin, E. K. Truman, G. A. Urquhart, R. A. Van Cauwenberghe, R. Van Leeuwen, R. Van Leusden, S. P. Wake, H. Wall, V. A. Wehrle, L. J. Whitney, G. Wiebe, M. L. Wiederhold, T. J. Wignall, N. D. Wilson, W. C. Wilton, J. R. Wolczuk, C. D. Woodman, W. E. Wotherspoon, L. T. Wotton, B. L. J. Young.

University of British Columbia: M. A. Alexander, D. G. Allen, W. G. Allen, P. T. Ambrose, D. L. Andrews, R. C. Atkinson, G. M. Austin, H. R. Baird, R. W. Baker, C. Beishuizen, D. J. Bensted, I. G. Blown, J. C. Bottaro, B. F. Caddick, I. C. Campbell, K. C. Carriere, Q. S. Chow, L. Claassen, G. A. Clark, F. Condon, R. M. Crotogino, A. De Paoli, P. Dunlop, G. A. Edgson, J. R. Emery, R. V. Everett, C. T. Eyford, F. N. Fenger, D. R. B. Ferguson, D. R. Forbes, C. T. Galazka, G. E. Gatz, W. J. Hassard, C. N. Hosein, A. C. Hume, B. Y. B. Kan, R. E. Karyula, M. Korsch, R. F. Krueckl, E. G. Langford, K. W. Lee, A. F. Lill, R. K. H. Lo, J. C. Longridge, G. W. Lorimer, J. P. Lucas, G. L. W. MacDonald, F. T. Man, T. Mar, F. G. McCaffery, R. D. McDonough, G. A. McKenzie, L. S. McKenzie, L. S. McQuillan, R. T. Mitchell, A. D. Murray, D. W. Nairne, H. Nishimura, W. E. Norquist, R. M. Painte, D. L. Palmer, K. H. Pang, W. P. Penz, E. B. Pickard, R. A. Provan, R. W. Pugh, K. W. Putt, J. E. Rands, W. A. Reid, D. E. Reksten, A. A. Robinson, K. E. Robinson, C. J. Rogers, G. R. Rosseau, A. D. Ryneveld, C. M. Scott, P. F. Scott, J. F. Shepard, J. D. Spence, F. C. Stephens, R. M. Stubbs, J. W. Sutherland, D. Templeman-Kluit, G. H. Thomson, L. R. B. Vermette, R. N. Vyse, M. W. Wanstall, D. M. Ward, M. C. Whetter, R. R. Whitaker, D. A. White, R. J. Williams, R. R. Williams, M. P. Wong-Char, B. O. O. Zeitz, R. Zingel.

McGill University: M. Albisser, P. Allisma, J. Altshuller, A. Auerbach, R. M. Brass, E. Brobbey, A. P. Bruckner, W. E. Cox, M. A. Donelan, J. C. Dunfield, R. J. Duveau, J. D. Eberts, G. O. Elliott, M. Z. Fabierkiewicz, H. A. Fielding, M. Florian-Iosipovici, J. P. Frappier, R. Gallay, J. G. Gooch, G. R. Gougeon, N. Guillemette, R. S. Hucal, P. R. L. Jones, R. O. W. Kuehnel, N. C. Lalla, S. W. Law, S. Margel, G. P. Mende, M. A. Millard, K. W. Neale, K. J. L. O'Connell, P. A. O'Hara, P. N. Okuma, L. M. Palacio, R. Parent, J. Pill, J. W. Presley, P. F. Rhead, C. Simoneau, H. R. Stevens, S. S. Sufi, L. P. Tawrell, A. S. Tsoukanas, L. E. Vikander, L. N. Weinstein, R. Weiss, I. L. Werba, C. A. Wong, G. P. C. Yue.

Laval University: J. C. Audet, J. J. A. Carrier, J. G. B. Dallaire, M. Drouin, R. Fortin, Y. Gaumond, J. A. P. Giroux, J. M. Huard, Y. Labbe, P. Leblanc, G. Morest, A. Morin, C. Pelchat, A. Pellerin, E. Plante, B. Ringuette, G. Robitaille, J. A. Servant, L. Tremblay, R. A. Tremblay.

McMaster University: J. W. Birett, J. A. Enright, D. A. Gedcke, K. A. Schmidsrauter, R. L. Smith.

Carleton University: J. B. Alexander, R. R. Whiting.

University of New Brunswick: J. R. Allen, F. J. Beairsto, T. F. Blanchard.

Queen's University: P. S. Taylor.
Mount Allison University: S. H. Wong.
University of Alberta: J. S. Watts.

St. Francis Xavier University: J. F. J. MacLean.

Coming Events

The Chemical Institute of Canada. Chemical Economics Division. Meeting. Toronto. April 3.

American Institute of Electrical Engineers. Conference on Electrical Problems in the Cement Industry. St. Louis. Mo.

American Society of Mechanical Engineers, Society of Advancement of Management. Management Engineering Conference. New York. April 5-6.

American Institute of Electrical Engineers. Rubber and Plastics Conference. Akron, Ohio. April 9-10.

American Welding Society. Annual Meeting and Welding Exposition. Cleveland, Ohio. April 9-13.

American Society of Mechanical Engineers, American Institute of Electrical Engineers, Engineering Institute of Canada. Railroad Conference. Toronto. Ont. April 10-11.

Geological Association of Canada, Canadian Institute of Mining and Metallurgy. Joint Annual Meeting. Ottawa. Ont. April 23-25.

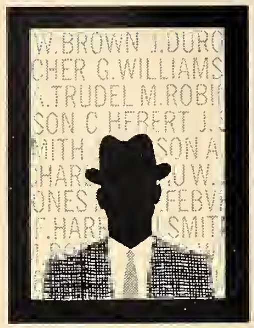
Engineering Institute of Canada. Fourth Southern Ontario Regional Conference. London, Ont. April 28.

Association of Iron and Steel Engineers. Spring Conference. Detroit. Mich. April 30-May 2.

Canadian Nuclear Association. Annual Meeting and Conference. Ottawa. May 28-30.

Engineering Institute of Canada. Annual Meeting. Montreal. June 12-15. EIC

Personals



H. W. S. Marshall, M.E.I.C. (Royal Tec. '38) has been appointed to the board of directors of Ewbank, Tupper and Associates Ltd., of Toronto, in the recent re-organization and change of name and ownership of that company. Mr. Marshall was previously Head of the Electrical Division with Ewbank & Partners (Canada) Ltd., and will also be in charge of Electrical Engineering with the reorganized company. Before joining the company in 1960, Mr. Marshall was Head of General Engineering with the Iraq, Basrah and Mosul Petroleum Companies Ltd., Baghdad, Iraq.

Commodore Frank Freeborn, RCN, M.E.I.C. has been appointed to the Board of Directors of Bedard Girard Limited, Montreal to replace the late **William H. Girard.** He will be situated at the company's Ottawa office. Prior to his retirement from RCN, Mr. Freeborn was Director General Ships.

Jasper H. Ings, M.E.I.C. (Tor. '31), Consulting Engineer of Niagara Falls, has been elected as the Canadian member of the Council of the Institution of Civil Engineers of Great Britain. Mr. Ings is Vice-President and Director of H. G. Acres & Company Limited, international consulting engineers. He has been active in engineering for hydro-electric power for more than 30 years.

Ross E. Chamberlain, M.E.I.C. (McGill '51) has been appointed to the newly-created position of manager, product development at Dominion Bridge Company Ltd. Mr. Chamberlain, who has been design engineer of the structural division at the Montreal Branch, now joins marketing services following wide experience on several major projects.

H. E. Marshall, M.E.I.C. (U.N.B. '41) has been promoted to the post of manager of the planning and operations division of the New Brunswick Electric Power Commission. Mr. Marshall joined the Power Commission in 1945.

Thomas E. Morimoto, M.E.I.C. (Univ. Alta. '49) has been appointed to the position of Chief Engineer of Montreal Engineering-Mannix. Mr. Morimoto has been chief process engineer with Brown & Root Ltd. in Calgary for the last four years. His twelve years' experience in the petro-chemical field includes two years as chemical engineer with the Polymer Corporation, three years with the Canadian Chemical Company and three years with the Research Council of Alberta.

Gordon S. Currie, M.E.I.C. (McGill '56) has been appointed Engineering Representative of Stone & Webster Canada Limited. Prior to joining this company, he was associated both in Canada and in Europe with a prominent firm of Manufacturers of power equipment.

H. J. Lemieux, M.E.I.C. (Ecole Poly. '39) has sold his interests in an Alma, Que. consulting firm which he formerly operated, to devote full time to Lemieux & Tetrault, who have offices in Montreal, Laprairie and Longueuil, Que.

D. A. Hansen, P.Eng. M.E.I.C. (Alta. '28), a Director of the Canadian Electrical Association, and General Sales Manager, Calgary Power Ltd., has been appointed Vice-President of the Association for the balance of the 1962 season. Mr. Hansen replaces **J. H. Steede** who has resigned.

Geoffrey C. Hamilton, M.E.I.C. (Sask. '45), Planning and Development Commissioner of the City of Edmonton, has been appointed to the Alberta Industrial Development Board. He will represent Edmonton in the provincial group which comprises representation from 18 Alberta cities. Mr. Hamilton took office as City Commissioner on September 1, 1961.

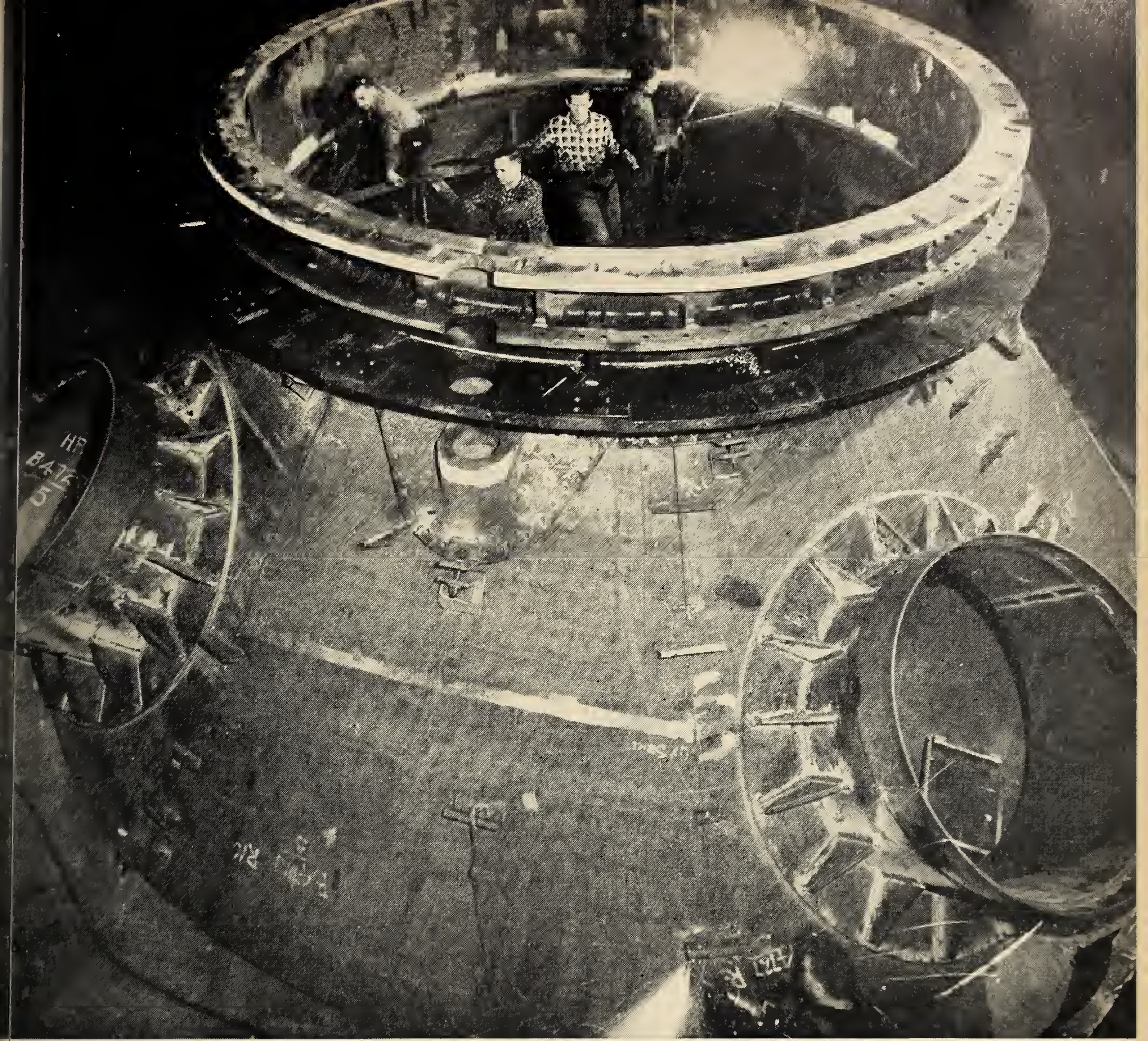
J. Edgar Dion, P.Eng., M.E.I.C. (McGill '26) has been elected president of the Association of Consulting Engineers of Canada for 1962 succeeding **John H. Ross** at Toronto. Mr. Dion, ACEC Vice-President in 1961, established his own consulting management engineering firm in 1947.

R. L. Grassby, M.E.I.C. (McGill '42) has been appointed manager, thermal equipment and pump products, at Montreal Locomotive Works Limited. Mr. Grassby joined Montreal Locomotive Works in 1956 as assistant to the president and was later made manager of business development and planning. Prior to his present appointment, he was sales manager, thermal products.

Harold V. Page, M.E.I.C. (Tor. '43), Sarnia Works Manager, Dow Chemical of Canada Limited has been transferred to Dow Chemical International A. G. In his new assignment, he will act in a production management capacity, and will make his headquarter temporarily in Midland, Mich. and later overseas. Mr. Page joined Dow Canada in 1951 in the Construction Department and in 1956 was appointed Plastics Division superintendent. In 1958, he was appointed works manager of the Sarnia operations. He is Past Chairman of the Sarnia Branch and was Branch Councillor at the time of his transfer.

Robert A. Reid, M.E.I.C. (McGill '42) has been appointed manager, marketing services at the Dominion Bridge Company Ltd. office in Montreal. Mr. Reid was formerly general manager of the Winnipeg branch of the Company, and since 1959, has been manager of manufacturing services at Head Office, a position he still retains.

A. C. R. Albery, P.Eng., M.E.I.C., has been appointed chief engineer and general manager of Canadian operations for Sir Alexander Gibb & Partners and Gibb, Underwood McLellan, Consulting Engineers of Toronto. Mr. Albery, a graduate of Cambridge University, has been with the company since 1958. Prior to coming to this country, Mr. Albery was in charge of Sir Alexander Gibb and Partners' operations in New Zealand, and before that, resident engineer with the company on the Hume River Hydro Electric Project on the River Murray in Australia.



News of the Branches

Border Cities

William C. Luciani, M.E.I.C.
Correspondent

Dr. G. S. Bull, Professor of Engineering Science, McGill University, was the guest speaker at the January 18 meeting held at Assumption's University Centre. Dr. Bull, formerly with Defence Research Board of Canada, spoke on Laboratory Space Research. Canada has no space rockets to fire, he said, but is playing a vital role in space research through laboratory research. He said the research in Canada began with a need to know the characteristics of a missile entering the earth's atmosphere at a high velocity. A technique of firing nose cones from guns at velocities similar to that of a body entering the atmosphere was pioneered in Canada. Many scientists believe it impossible to build the guns necessary and impossible to measure effects on the nose cone. There is also a need to be able to identify these missiles by the brightness, color and other aspects of their luminous trail. Such information is also useful in contributing to knowledge of meteors by analogy, and to the knowledge of space travel.

Brockville

A. N. Campbell, M.E.I.C.
Correspondent

A joint meeting of the Branch and the local branch of the Chemical Institute of Canada took place on January 11. Seventy-five engineers and chemists were present. Joint chairmen of the meeting were Dr. M. Kirkwood, Chairman of the E.I.C. Branch, and J. B. Moriarity, Chairman of the C.I.C. Branch.

"Opportunities for Engineering and Science Graduates in Industry, and What is Expected of Them by Industry" was the topic for the panel discussion. G. R. Dance, Du Pont of Canada, Maitland Works, was moderator and panelists were: A. T. Fell, Works Manager, Maitland Works, Du Pont; T. A. Lindsay, President, Phillips Electrical, Brockville; and R. A. Ward, Sales Manager, Metalbestos Manufacturing Co., Brockville. Each of the panelists gave a view on the topic as it applied to his particular company. The discussion was followed by a lively question-and-answer period.

Members of the 1962 executive are: J. B. Moriarity, Chairman; D. B. Ashenden, Vice-Chairman; W. R. Hammond, Secretary-Treasurer; J. R. Eastwood, Past Chairman; A. N. Campbell, Publicity and Junior Activities; R. F. Mucklestone, Membership Chairman.

The Branch and the local C.I.C. sponsored a Science Fair at the Thousand Island Secondary School on February 24.

Central British Columbia

A. F. Joplin, M.E.I.C.
Correspondent

A joint meeting of the Central British Columbia Branch and the A.P.E.B.C. was held January 19, at the Roundup in Vernon. Retiring Branch Chairman J. W. Nelson presented a report on the Annual Meeting of the Association. After a discussion of a proposed program for 1962, the B.C. Department of Highways showed three films dealing with engineering projects of the Department. The films shown were: "Construction of Deas Island Tunnel"; "Fraser Canyon Highway"; "Construction of Tsawwassen Ferry". The films were well received, and G. S. Hirtle proposed a vote of thanks from the Branch for the interesting program.

Estevan Section

O. P. Lesiuk, M.E.I.C.
Correspondent

Harley Strain, Chief Mine Geologist at International Minerals and Chemical Corporation, Esterhazy, Sask., was the guest speaker at the Branch's January 9 meeting. His talk, entitled, "Shaft Sinking for Potash", dealt with the problems encountered in sinking a shaft 3,000 feet to the potash beds. The method of Tubbing to overcome the water-saturated Blairmore formation was dealt with in some detail. The mining of the potash at Esterhazy, by the Room and Pillar Method, is expected to begin by summer 1962. The expenditure on exploration, shafting and plant equipment is expected to exceed $50 million before actual mining operations can begin. Mr. Strain's talk was illustrated by a color film of the Esterhazy project.

A $100 scholarship will be presented to a deserving graduate of the Estevan Collegiate entering an Engineering College. The officers for 1962 are: Chairman, C. Urrenbach; Vice-Chairman, J. Stephenson; Secretary - Treasurer, G. Funke; Social Convenor, G. Hedges; Program Convenor, G. Smith. Jim Strain was thanked for his work with the Branch. He has been transferred to Regina.

Kitchener

A. R. Le Feuvre, M.E.I.C.
Correspondent

Dr. B. G. Ballard, President of the Engineering Institute of Canada was the guest speaker at the Branch's Annual Meeting held January 19. The meeting was well attended and among the 84 present were the guests from the Grand Valley group of engineers. Dr. Ballard discussed the Confederation Committee Report. He outlined the approach of the Council, and pointed out the pros and cons on this subject. A lively discussion followed during which members expressed their wishes for more information and guidance from the Council regarding Confederation. This information, they said, would enable them to make a more intelligent decision when a vote is taken.

The new executive, including Chairman R. Dahmer; Vice Chairman, C. G. E. Downing; Secretary Treasurer, E. H. Wilson; and Directors, W. L. Bulmer, M. H. Schmitt, W. G. Mayberry and W. N. Meikle took office at this meeting. The new Chairman Ray Dahmer, was presented with a new gavel, and the retiring Chairman was also presented with a gavel in recognition of his fine work during his term in 1961. During the meeting, Dr. Ballard presented Technical Essay Prizes to two University of Waterloo Engineering students. W. Bowes received the first prize of $25, and second prize was presented to K. Reichert.

(Continued on page 88)

Library Notes

Prepared by the Library, The Engineering Institute of Canada

Book notes marked by an asterisk have been provided through the courtesy of The Engineering Societies Library in New York.

BOOK REVIEW

STEELS FOR REACTOR PRESSURE CIRCUITS.

The report of a symposium held in London in December 1960 by the Iron and Steel Institute for the British Nuclear Energy Conference, this volume contains both the twenty-five papers presented, and the discussion they aroused. The five sessions covered: high-temperature properties of steels; corrosion; fabrication of reactor pressure vessels; the effects of irradiation on steels; and steels which will be required for reactors in the future. (London, Iron and Steel Institute, 1961. 587 p., 65/-.)

*FILTRATION.

Solid-liquid separation in water, industrial products, and wastes is covered. A comprehensive study of filtering is given, including a brief summary of pertinent mathematical theories and formulas. Current design and construction of the various classes of filters are presented and illustrated, and operating practices and resultant data are included. Special attention is given to diatomite filters for swimming pools and potable waters, and increased yields from new additives in the filtration of uranium ore and other sludges. (G. D. Dickey. New York, Reinhold, 1961. 353p., $12.00.)

*AMERICAN BUILDING ART: THE TWENTIETH CENTURY.

This volume continues the story of building techniques and structural art begun in "American Building Art: The Nineteenth Century". It reviews down to the present the profound changes in technology and in American society that have produced meaningful structures. The author assesses such structures as steel frames, the metropolitan railway terminal, steel truss and girder bridges, steel arch and suspension bridges, concrete building construction, concrete bridges, concrete dams and waterway dams and waterway control, and the metropolitan parkway. (C. W. Condit, Toronto, Oxford, 1961. 427p., $15.00.)

ESSENTIALS OF ENGINEERING FLUID MECHANICS.

An undergraduate text covering the principles of fluid mechanics, showing how they are used in all fields of engineering. The chapters cover fluid properties; thermodynamics; fluid statics and dynamics; potential flow; the boundary layer in incompressible flow; dimensionless numbers; the flow of compressible gases; flow in conduits; dynamic drag and lift; open-channel flow; flow measurements; turbomachines; gas flow in pipes and nozzles; convective heat transfer. (R. M. Olson. Scranton, International Textbook, 1961. 404p., $10.50.)

*COMPRESSED AIR AND GAS HANDBOOK, 3rd. ed.

This edition has been thoroughly revised and includes many topics of increasing interest. Specifically coverage is now given to materials handling systems, air circuitry and controls, air gaging, specialty tools, automation components, and process gas compressors. Factors to be weighed in selecting the centralized or unit-type compressed air system, or in correcting an inadequate system, are stated. There is a complete, up-to-date discussion of the various types of compressors and of pneumatic tools of both industrial and construction types, with well illustrated examples of their application. (New York, Compressed Air and Gas Institute, 1961. Various pagings, $8.00.)

THE ENGINEERING INSTITUTE LIBRARY

The publications mentioned in these notes are now available in the Library, and may be borrowed by members of the Institute. Two items may be borrowed at one time for a period of two weeks, excluding time in transit.

Library hours are: Monday to Friday: 9 a.m. to 5 p.m.; Saturdays: 9 a.m. to 12 noon. All requests and enquiries should be addressed to the Librarian at 2050 Mansfield Street, Montreal.

*BARRAGES MOBILES ET PRISES D'EAU EN RIVIERES, 2. ed.

A study of movable dams and water-intake systems in rivers, covering such aspects as rate of water flow, water levels, drift of alluvial deposits, and flow through sluices. The construction of gates, coffer dams, and sand and gravel filtering devices is also considered. This second edition contains a new chapter on intakes for use in rivers with considerable slope. (M. Bouvard. Paris, Eyrolles, 1960. 267p., 29.45 NF.)

DESIGN AND CONSTRUCTION OF FOUNDATIONS.

Intended for civil engineers in general practice, the foundations considered are those which would normally be undertaken without calling in an expert. The author commences with a discussion of site investigations, loading tests, applied loads and settlement. The types of foundation covered are reinforced concrete slab footings, beam and slab footings; raft, driven-pile and bored-pile foundations; caissons; and foundations on submerged sites. (G. P. Manning. London, Concrete Publications, 1961. 234p., $6.00.)

*BIBLIOGRAPHY OF HYDROMETRY.

A thorough and comprehensive record of scientific investigations into hydrometry, this systematic bibliography contains 7370 titles of papers in more than thirty languages. The entire subject of hydrometry is broken down into twenty-four sections, with entries arranged in chronological order within each section. Brief annotations are given for each entry. (Steponas Kolupaila. Notre Dame, University of Notre Dame Press, 1961. 975p., $10.)

*PROGRESS IN SOLID MECHANICS, VOL. II.

Authoritative surveys of recent developments in the various branches of solid mechanics, both theoretical and experimental, are presented. This volume discusses large elastic deformations, elastic waves in anisotropic media, elastic inclusions and inhomogeneities, plastic waves, measurement of dynamic elastic properties, discontinuity relations in mechanics of solids, and the stability of elastic-plastic structures. (I. N. Sneddon and R. Hill. New York, Interscience, 1961. 331p., $11.75.)

(Continued on page 89)

Business and Industrial Briefs

Appointments and Transfers

The Kruger Organization Ltd., Montreal, has announced the election of **Gene H. Kruger** as Chairman of the Board, **B. J. Kruger** as President and Chief Operating Officer, and **John T. Dodds** as senior Vice-President. Mr. Gene Kruger will also remain a director of the company.

H. Robert Burton, traffic engineer and consultant, has been appointed a Director of the Institute of Traffic Engineers. Mr. Burton will hold office for two years. Mr. Burton is traffic consultant with the firm of H. G. Acres, Niagara Falls, Ont.

J. R. Miller, General Manager of Polymer, Belgium, has announced the appointments of **John H. Gulliford, Charles A. McKenzie** and **James H. Watt** to the staff of Polymer's new butyl rubber subsidiary in Belgium.

Canadian Longyear, diamond drilling contractors and manufacturers has announced the appointment of **Donald Allan Elliot** as assistant to the manager of the contract drilling division. Since graduating from the University of Toronto in 1937, Mr. Elliot has been employed by Dravo of Canada Limited as a construction superintendent.

Fred Snell has been appointed Vice-President in charge of operations at the Okanagan Helicopter Ltd. He was chief pilot of the Okanagan group, and was promoted to Operations Manager in 1956.

The CBC International Service has announced the appointment of **Basil (Pip) Duke** as Supervisor of Engineering Services. Mr. Duke will supervise operations of the Service's shortwave transmissions in eleven languages directed to Europe, Latin American, Africa, the Caribbean area, and Australia. His work will also include the shortwave engineering supervision of the CBC's Northern and Armed Forces Services.

Gerald Des Laurier has been named Sales Engineer for Canadian Zurn Industries Ltd. Mr. Des Laurier will travel throughout the Province of Quebec for the Company.

Jean Lamarche, previously assistant manager, of Montreal district, Atlas Copco, has been appointed District Manager. **Larry O'Shaughnessy**, previously deputy district manager, at Truro, N.S., will become manager of the District. Formerly representing the company in Newfoundland, he joined Atlas Copco in 1960.

E. W. McBride, Vice-President (Manufacturing) Abitibi Power & Paper Company Ltd. has announced the appointments of **G. A. Sutton** as Mill Manager of Iroquois Falls Division and **J. B. Papoe** as Mill Manager of the Fort Williams Division.

Canadian Industries Limited has announced the appointment of **M. H. McKelvey** as local sales manager for explosives for the Kirkland Lake and Noranda Territories. Mr. McKelvey Joined C-I-L in 1929, in Toronto and most recently was sales manager in Noranda, Que. The Company also announced the appointment of **H. N. Christensen** as local sales manager for explosives at Elliot Lake, Ont. Mr. Christensen joined C-I-L in 1953 at Toronto and was local sales manager at Kirkland Lake, Ont.

Canadian Westinghouse at Hamilton has announced the appointment of **Mark C. Lowe** as Manager of the Manufacturing and Repair Division, and **Carl Pollock** as manager of the Air Brake Division. The two men were assistants to the Vice-President, Heavy Apparatus, and Manager, Budget Administration, respectively.

R. S. Mulholland has been appointed Works Manager of the Sarnia plant, Dow Chemical of Canada Ltd. Mr. Mulholland joined Dow in 1948 and in 1960 was appointed Assistant Works Manager of the Sarnia operations.

W. L. Notman has been appointed Manager, Manufacturing services at Montreal Locomotive Works Limited. Mr. Notman has been with the company since 1948, and has served in various capacities of the company's manufacturing and sales operations. He has been assistant to the President since 1958.

Harmon S. Eberhard, President of Caterpillar Tractor Company since 1954, has been elected Chairman of the Board. **William Blackie**, Executive Vice President was elected President to succeed Mr. Eberhard.

Developments

Information contained in this section has been obtained from press releases. Mention of products and services does not imply endorsement by the Institute.

THE DANFOSS Manufacturing Company of Port Credit, Ont. has introduced the Type RA Thermostatic Radiator Valve, a self-contained non-electriczone valve. The type RA is a unit suitable for all types of radiators including baseboard, convectors, free standing radiators. Being self-powered by means of a liquid charge the unit is independent and needs no electrical wiring. The liquid expands and contracts in accordance with room temperature and thereby modulates the supply of heat.

INTERNATIONAL BUSINESS MACHINES has announced a new family of modular electronic computers, the most versatile yet offered for scientific data processing. With their wide range of abilities, the systems are geared to the needs of firms with a varied data processing work load. A company could use one of the computers to develop a chemical process or test the wing design of a supersonic aircraft, as well as for management science functions such as job-shop simulation, project scheduling and linear programming.

A CATALOGUE describing its new line of fluorescent Shallow Line troffers, the streamlined look in recessed lighting, is offered by C & M Products, Scarborough, Ont. C & M is a subsidiary of Thomas Industries of Louisville, Ky.

(Continued on page 113)

DEXION
DEXI
DEXION

FOURTH SOUTHERN ONTA

The Enginee

Hotel Lon

Satur

Sponsoring Branches

London

Sarnia

Windsor

YOUR CONTINUING FAVORABLE RESPONSE to and support of the Regional Conference concept has been accepted as a challenge by the Sarnia, Windsor and London Branches of the Engineering Institute of Canada. The program has been thoughtfully planned to provide the best possible opportunity to discuss the most recent developments in various fields of ENGINEERING

10:00 a.m. Representatives of Sponsoring and Participating Branch Executives Meet

10:30 a.m. Mezzanine Floor—Registration — Advance Registration Forms Will Be Mailed To Participating Members and A.P.E.O. Members In The Area.

Noon Grosvenor Room—Men's Luncheon

1:00 p.m. Grosvenor Room—opening of Conference, *Dr. B.G. Ballard*, Hon. M.E.I.C.

1:05 p.m. Grosvenor Room—"Trends in Engineering Education"

R. M. Dillon B.A., S.M., M.E.I.C.
Dean of Faculty of Engineering
University of Western Ontario

W. A. Thompson A.B., M.B.A.
Associate Dean of Business Administration
University of Western Ontario

D. D. C. McGeachie B.Sc., Dipl. B.A.
Vice-President and General Manager
Wolverine Tube Division
Calumet & Hecla Canada Ltd.

Mr. McGeachie will moderate this interesting and vital discussion dealing with the development of a most important aspect of contemporary education, namely a proper relationship between "Engineering" and "Business Management".

2:15 p.m. BREAK

2:30-5:00 p.m. Grosvenor and Regency Rooms—TECHNICAL PROGRAM

6:00 p.m. Georgian Room—RECEPTION

7:00 p.m. Regency Room—DINNER

8:15 p.m. Regency Room Special Guest Speaker
"75 Years of Engineering Progress"

Dr. A. D. Misener, M.A., Ph.D.,
Director, Ontario Research Foundation

His critical review of the subject will serve as a guidepost to our progress and as a goal for our future.

9:15 p.m. Regency Room DANCE Dress Optional
Bobby Downs Orchestra

Midnight The National Anthem

Members and Ladies
plan now to register in advance
for this important event

SEVENTY-FIVE YEARS

IONAL CONFERENCE

tute of Canada

lon, Ont.

l 28, 1962

Participating Branches

Brampton, Hamilton, Kitchener,

Niagara, Oakville, Peterborough,

Port Credit, Richmond Hill,

Toronto, Whitby

THE SPECIAL LADIES PROGRAM

ensures that your lady will likewise find the occasion very much worthwhile. The ladies of the sponsoring Branches have arranged a program tailored to Southern Ontario spring weather. Transportation in the afternoon will be available as required. We look forward to meeting with Y-O-U

TECHNICAL PROGRAM GROUP I

:30 p.m. "Practical Applications of Recent Advances in Soil Mechanics".

Professor L. G. Soderman B.Sc., D.I.C., M.E.I.C.
Faculty of Engineering Science University of Western Ontario

This paper proposes to discuss the more practical implications of recent advances in the science of soil mechanics and its emergence as a discipline of Engineering Science. Particular reference will be made to spread footings, piled foundations and flexible bulkheads, as they relate to the recent advances in the understanding of soil mechanics. Prof. Soderman has worked in industry as a consulting engineer and in government service, and now is lecturing in soil mechanics at both the University of Western Ontario and the University of Toronto.

MODERATOR—*N. M. Warner*, B.A.Sc., M.E.I.C.
R. C. Dunn Associates Ltd. London, Ont.

2:30 p.m. "The Industrial Group Relationship of the Engineering Profession to Management".

J. G. Guthrie, B.Sc., M.E.I.C.
Chief Construction Engineer Imperial Oil Limited, Sarnia

This paper outlines the development of industrial group relationship with management during the last 75 years and in particular the changing relationship of the engineer. Past contractual, personnel and human relationship policies are discussed. Opinions are expressed as to the success of these relationships and policies, and what future relationships will satisfy both the professional engineer and the manager.

MODERATOR—*R. F. Routledge*, B.Eng., M.E.I.C.
Chief Operations Engineer
Imperial Oil Limited, Sarnia

:30 p.m. COFFEE BREAK INFORMAL DISCUSSIONS

TECHNICAL PROGRAM GROUP II

:45 p.m. "Nuclear Power Generation Economics — Design — Construction".

D.L.S. Bate, B.A. Sc., M.E.I.C.
Senior Engineer A.E.C.L. (H.E.P.C.)

The different approaches to economical power generation using atomic energy, the economic and technical advantages of different reactors, the current Canadian developments, and the design and progress of the Douglas Point Generating Station will be discussed. The paper will be illustrated with slides.

MODERATOR—*L. S. Lauchland*, M.A.Sc., M.E.I.C.
Professor and Assistant Dean of Faculty of Engineering
University of Western Ontario

3:45 p.m. "The Plastic Industry— Seventy-Five Years of Growth"

J. Stoesser, B.A. Sc.,
Manager Technical Service and Development Dow Chemical Canada

Between the introduction of cellulose nitrate in the late 1800's and chlorinated polyethers in 1959 several dozen other plastic materials have evolved commercially. The sale and use of these materials now represent Canadian business in excess of $25,000,000. Chronologically the evolution of some of the major plastic materials is unfolded with brief description of their properties and main end uses. Methods of fabrication are covered in sufficient detail to introduce the versatility of the materials. The talk closes with a view to the future, anticipating some of the demands that will be made upon plastics and indicating some of the features being tailored into plastics to meet these needs.

MODERATOR—*C. R. Young*, B.A.Sc., M.E.I.C.
Supervisor of Construction Dow Chemical of Canada

FOR THE LADIES

10:30 a.m. Hotel London Registration and Coffee Hour
12:30 p.m. Armouries (in Hotel London block) Luncheon and Special Fashion Show
3:00 p.m. Shopping—Visiting—Sightseeing. Storybook Gardens—Eldon House—University
6:00 p.m. Georgian Room Reception—Rejoin the Gentlemen

INEERING ACHIEVEMENT

Lakehead

P. W. Pinn, M.E.I.C.
Correspondent

A tour of Dorans Brewery, Port Arthur, took place January 22 following a brief business meeting at which the members discussed confederation. R. J. Waas, Production Manager of the brewery, conducted the tour and explained the processes involved. Refreshments were served after which L. Harelman proposed a vote of thanks to Mr. Waas for the interesting evening.

Nipissing and Upper Ottawa

J. S. Cooper, M.E.I.C.
Correspondent

A dinner meeting attended by 43 members and guests was held January 17 at the King Edward Hotel in Sturgeon Falls. Frank Clarke welcomed the gathering on behalf of the Abitibi Power and Paper Company, Ltd., and explained briefly the mill inspection trip which was to follow. On arrival at the mill the party was divided into groups of about six members each, and with a guide were conducted on a tour which included the diversified operations of the corrugating, hard-board and particle board departments. Branch Chairman R. A. Booy expressed the appreciation of the guests to the Company.

Saint John

Garnet Phinney
Correspondent

The annual meeting of the Branch was held recently at the Royal Hotel. Douglas Higgins was elected chairman, M. C. Schofield, Vice Chairman, and Eldon Thompson, Secretary-Treasurer. G. A. Phinney and H. S. McCleave were elected members of the executive committee. The guest speaker was A. P. Connell who described Wildlife in the Canadian North. His talk was illustrated with several movies on the wildlife of the region, glacier flows and life in Eskimo villages. Retiring Chairman P. W. Hastings in reviewing the past year's activities, said the well-attended meetings and increase in membership were partially due to the professional development course currently being conducted for members of the branch.

Winnipeg

Peter M. Abel, A.M.E.I.C.
Correspondent

The Branch held its Annual Meeting at Luigi's Banquet Hall in the Pembina Hotel. The guest speaker at the dinner meeting, General Secretary Garnet T. Page, was introduced by J. R. Rettie Mr. Page discussed the problems of the Institute, then dealt at length with the "Journal" "Transactions", the Library Finances, and the Employment Service He also reviewed the history of the Institute, and discussed some aspects of confederation. He succeeded in clarifying a number of misconceptions and misunderstandings about these subjects Mr. Page was thanked by Dr. D. M Stephens, past president of the Institute.

At the meeting, the secretary-treasurer of the Branch gave his annual report Dean A. E. Macdonald made the announcement that Kenneth A. Peebles S.E.I.C., a student at the University of Manitoba's Engineering Faculty was the winner of the E.I.C. Award which was presented by the General Secretary Dean Macdonald then introduced the winners of the Athlone Scholarship, and gave a brief history of the scholarships The Winners of the two-years work and study program in Great Britain were Erik R. Sigurdsen, IV Engineering Physics; Melvin C. Griffith, IV Electrical; and J. Leslie Crosthwaite, IV Mechanical.

Oakville

A. A. Swinnerton, M.E.I.C.
Correspondent

The Branch's Annual Meeting was held as a Dinner-Dance at the Coach Room of the Country Squire. It was a very successful meeting with an attendance of 62. During the business meeting the following officers were elected for 1962: Chairman, J. A. Ale

nder; Vice Chairman, C. F. Gross; ecretary-Treasurer, R. Montrose; Counllor, A. H. Thompson; Program, S. C. mith; Membership, J. A. West.

askatoon

. J. Warder
'orrespondent

Dr. J. B. Mawdsley, Dean of Eninecring, University of Saskatchewan, as the guest speaker at the Branch's anuary 16 banquet meeting at Jay)ee's. In the opinion of Dean Mawdsy, engineers will be in great demand this rapidly expanding economy of anada with its rapid technological adances. Dean Mawdsley then sumarized the problems of educating nough engineers to meet the needs of e era, and deciding who should be ained as a scientist, an engineer, or a chnician. At the present time, he said, ere was a demand for engineers in ractically all lines, greater than could e met from the supply of good men. Ie mentioned that the number of eninecring students at the University of askatchewan was remaining practically table while the number of other stuents was expanding. This trend was pparent in universities in other proinces as well. Dean Mawdsley said it vas difficult to find reasons for the relaive decline. "Why," he asked, "should ure science be more attractive to freshnen than engineering?" He said some ersons maintained that the discoveries f recent years, radar, transistors, nulear power, had resulted in the glamorzing of pure science. The engineer is he middleman between the scientist and echnician, and engineers are needed by his country to maintain our way of life.

Dean Mawdsley, in concluding, foreaw a marked increase in enrolment in he college of engineering. This increase vould result in a need for "much help" n supplying the necessary staff, buildngs, and scholarships. The need for all hese could not be overstressed.

Winnipeg, Civil Section

Mervyn Mindess, M.E.I.C.
Correspondent

E. Kuiper, Associate Professor of Civil Engineering at University of Manitoba, vas guest speaker at the January 25 neeting of the Branch. In his talk enitled "Hydraulic Aspects of the Grand Rapids Power Development", he described the various hydraulic problems involved in increasing the flow of the Saskatchewan River at Grand Rapids and constructing the water power development and its requisite dikes at that point. Prior to Professor Kuiper's talk, the new executive of Civil Section of the Branch was elected. Members are: Chairman, Gordon Denson; Vice-Chairman, R. A. McKnight; Secretary-Treasurer, W. A. Johnson; Papers Chairman, Journal Correspondent, Mervyn Mindess and Executive Members, L. Hurwitz and E. Overgaard. A vote of thanks was extended to the outgoing Chairman, Jim MacDonald, and his executive including Messrs. Denson and Johnson, for their fine handling of the Civil Section affairs in 1961. EIC

• Library Notes

(Continued from page 78)

*ATOMIC ENERGY WASTE.

This volume reviews the current knowledge concerning nuclear waste products and how they arise. Specifically, it discusses the effects of radiation on materials and living organisms, the legal aspects of atomic energy waste disposal, the operations involved in the treatment of radioactive waste, fission products as sources of radiation, and the uses of radiation in research and agriculture. Each aspect is discussed by a known authority within the respective subject area. (Ed. by E. Glueckauf. New York, Interscience, 1961. 420p., $14.00.)

*VERFORMUNG, SPANNUNG UND KERBWIRKUNG.

An introductory study on deformation, stress and notch effect intended by the authors as a supplement to books on the theory of elasticity. The material on notch effect by Thum and his pupils which had been scattered through many periodical articles is here considered as a whole. There are sections on deformation and stress; simple notch effect; restraint of deformation and multiple notch effect; and measurement of elasticity and stress. (A. Thum and others. Dusseldorf, VDI-Verlag GmbH, 1960. 103p., DM 14.60.)

(Continued on page 90)

Library Notes

(Continued from page 89)

*CONTINUOUS CASTING OF STEEL.

The development of current methods of the continuous casting of steel, both in the Soviet Union and in other countries, is discussed. In addition to a description of the equipment used, the parameters of the continuous casting of steel are also indicated. The results of comparative investigations of the quality of cast ingots produced by the normal method of casting into ingot molds are presented. This is a translation from the Russian. (M. C. Boichenko. Toronto, Butterworths, 1961. 218p., $9.50.)

*HANDBOOK OF NUMERICAL METHODS FOR SOLUTION OF EQUATIONS.

This work, which is translated from the Russian, is concerned with the solution of algebraic equations of third or higher order and of transcendental equations of an even more complicated nature. Various methods of calculation are described, combinations of which permit the solution of a wide range of problems. Special attention is paid to the more important methods, the basic concepts of which are expounded at length, and illustrated by numerical samples. In many cases original methods are introduced. (V. L. Zaguskin. New York, Pergamon, 1961. 195p. $6.50.)

*MODERN FURNACE TECHNOLOGY, 3rd.

The fields of combustion, gas fl and heat transfer are reviewed, and basic considerations which can be appl to any type furnace and to any fuel process are explained. Illustrative amples with typical calculations are p sented. Additional matter in this edit includes new sections on flames, au matic combustion controls, heat bala diagrams, gas friction calculations, a refractories which have recently been veloped commercially. (H. Ethering and G. Etherington. London, Griff 1961. 569p., £6.)

*PRESTRESSED CONCRETE CYLINDRICAL TANKS.

Methods are presented which redu the time required for calculating design and construction of a tank wh is most suitable for a specific purpo In particular simplified expressions developed for the design of fully mo lithic cylindrical tanks with rigid joi A chapter is devoted to the essen features of the construction proced required to ensure liquid tightness. feature of the volume is the descript of a number of selected examples prestressed cylindrical tanks which p sess some special characteristic of terest. (L. R. Creasy. New York, Wi 1961. 216p., $6.75.)

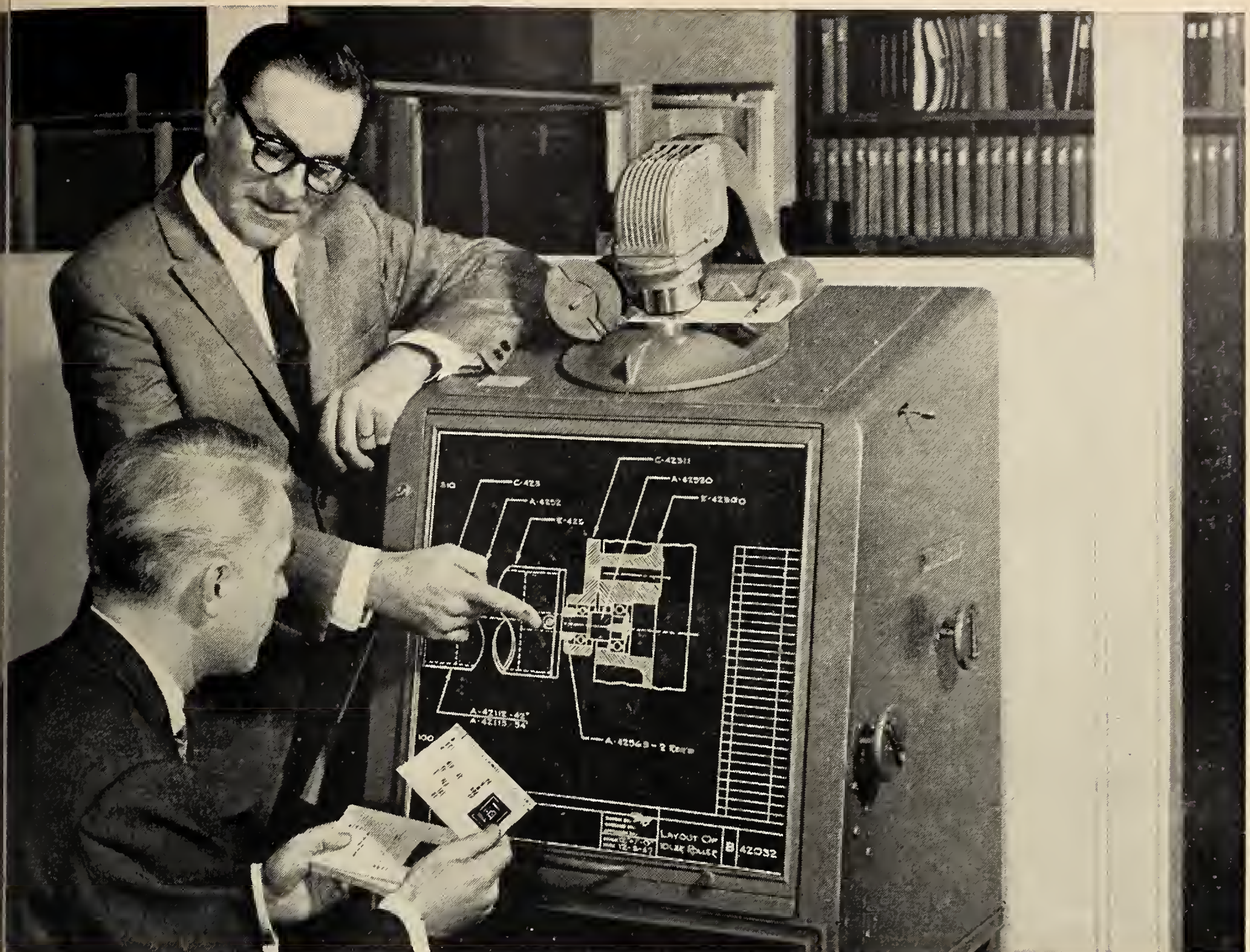
*INTRODUCTION TO MECHANICS OF CONTINUA.

Typical problems and methods mechanics of continua are presented a level which establishes the groundw for a more advanced study of hyd dynamics, gas-dynamics, plasticity, elasticity. The topics discussed incl geometrical foundations, state of str instantaneous motion, fundamental la perfect and viscuous fluids, visco-ela and perfectly plastic materials, hy elastic materials, finite strain, and ela and hyperelastic materials. (Will Prager. Toronto, Ginn, 1961. 23 $8.00.)

*DEMINERALIZATION BY ELECTRODIALY

Research in the application of electrodialysis process for the commer production of partially demineral water from brackish and sea water summarized. The broad outlines of electrodialysis process are presented, followed by a discussion of the phys chemistry and the determination of mechanical and electromechanical perties of ion-selective membranes. separate chapter is devoted to exp mental work carried out in develop parchment-based membranes. The b concludes with the factors to be sidered in the design of an elec dialysis plant, as well as the ac design and operation of a 2.4 mil gallon per day plant. (Ed. by J. Wilson. Toronto, Butterworth, 1 378p., $12.000.)

(Continued on page 92)



It's all there, every detail sharp and clear, in RECORDAK precision 35mm microfilm images

Library Notes

(Continued from page 90)

THE CALCULATION OF LOAD AND TORQUE IN HOT FLAT ROLLING.

Recent investigations have provided stress-strain data for different types of steel at temperatures and deformation rates applicable to the hot-rolling process. This has made possible the calculation of rolling load and torque in hot rolling by the use of formulae. The method of calculation is given in this volume, with the basic information required for calculation given in graphical form. Information is given for 12 types of steel at varying temperatures, and three additional types are covered in the supplement. (P. M. Cook and A. W. McCrum. London, British Iron and Steel Institute, 1958. 109p. and supplement.)

*METHODS FOR EMISSION SPECTROCHEMICAL ANALYSIS, 3rd. ed.

Standards, tentative standards, and proposed and suggested methods relating to emission spectrochemical analysis are included. The book is divided into four parts dealing with general practices. nomenclature, spectrochemical analysis of metals, and spectrochemical analysis of nonmetals. (Philadelphia, American Society For Testing Materials, 1960. 685p., $11.00.)

CIVIL ENGINEERING EDUCATION.

The study was sponsored by the Cooper Union, the American Society of Civil Engineers, and the American Society of Engineering Education, under a grant by the National Science Foundation. The purpose of the study was to evaluate the civil engineering curriculum, and put forward suggestions for its modification. The sessions covered such topics as the scope of civil engineering; the distinction between science and engineering; the "interchangeable core" curriculum; professional development; long-range goals in civil engineering education. (New York, A.S.C.E., 1961. 189p., $1.00.)

DYNAMICS OF REAL FLUIDS, 2nd. ed.

Largely revised, this edition contains new chapters on hypersonic flow, aerodynamic noise, particulate phenomena and magneto hydrodynamics, and the late author's experiments on the sounds of impact of a solid on a liquid surface, and those on the threshold and initiation of cavitation are described. Many figures and references are included. (E. G. Richardson. London, Arnold, 1961. 231p., $8.50.)

*ROHRLEITUNGEN IN DAMPFKRAFTWERKEN UND DAMPFVERBRAUCHENDEN BETRIEBEN.

This is a new edition of a volume on piping in power and process steam plants dealing with the applications and reliability of piping components under various operating conditions based on practical experience. Particular attention is paid to new requirements due to higher pressures and temperatures. German standards, specifications and rules are given for avoiding design and operating failures. The main practical portion of the book, dealing with structural components is preceded by a theoretical section on the calculation of pressure drop and heat losses in pipes, and the strength of pipes and flanges. The book also contains a list of the important German standards and specifications and a bibliography on piping. (Fr. F. Wiese and others. Dusseldorf, VDI-Verlag GmbH, 1960. 279p., DM 36.80.)

*PORE PRESSURE AND SUCTION IN SOILS.

This volume contains the proceedings of a conference held in London in 1960 which was organized by the British National Society of the International Society of Soil Mechanics and Foundation Engineering. Seventeen papers cover general principles and laboratory measurements; earth dams, embankments, and foundations; and roads and runways. Papers are given in English and French. (Toronto, Butterworth, 1961. 151p., $11.25.)

°PRESSURIZED PACKAGING (AEROSOLS), 2nd. ed.

This edition includes new material on compressed gases and formulations employing compressed gases, a section on legal regulations and a bibliography of relevant patents. As in the first edition, there are chapters on such topics as propellants, containers, filling methods, valves, laboratory procedures and perfumes. A section on formulations covers such widely different items as food, insecticides, cosmetics, paints and varnishes, medicinal preparations and dog shampoos. In addition trade names and patents and a world directory of suppliers are appended. References are listed at the end of each chapter. (A. Herzka and J. Pickthall. Toronto, Butterworth, 1961. 509p., $15.00.)

°TRANSVERSE VIBRATION THEORY.

Transverse vibrations of beamlike structures with many degree of freedom are investigated. The classical and better-known numerical methods for solving transverse vibration problems are first reviewed. A new method of equivalent systems is then developed, leading to the dynamic hinge concept. This permits a portion of the structure to be isolated and used for determining the fundamental frequency of vibration. The methods are general and applicable to the most difficult multiple-span, variable-stiffness structures. The theory applies to all beamlike structures, whether they are buildings, bridges, ships, airplane components, or mechanical devices. (D. G. Fertis and E. C. Zobel. New York, Ronald Press, 1961. 301p., $10.00.)

°FAILURE AND REPAIR OF CONCRETE STRUCTURES.

The chemical and mechanical failure of concrete is described and illustrated by photographs extending back over a period of thirty years. Methods of repair are then outlined, and the merits of slurrying, rendering, gunite, and spraying are discussed. Cracks and joints are dealt with particularly from a waterproofing point of view. A chapter on repair supervision concludes the book, and provides a review of the important points covered in the previous chapters. (S. Champion. New York, Wiley, 1961. 199p., $6.75.)

°TOUGHNESS AND BRITTLENESS IN METALS.

The four papers contained in this volume are the lectures delivered at the 14th Annual Refresher Course of the Institution of Metallurgists held at Eastbourne in 1960. They discuss the definition and significance of toughness and brittleness in metals, the engineering aspects of toughness and brittleness in metals, the effect of environment on embrittlement in metals, and the metallurgical aspects of ductility and brittleness in metals and alloys. (London, Iliffe, 1961. 108p., 27/6.)

°UNIT OPERATIONS OF SANITARY ENGINEERING.

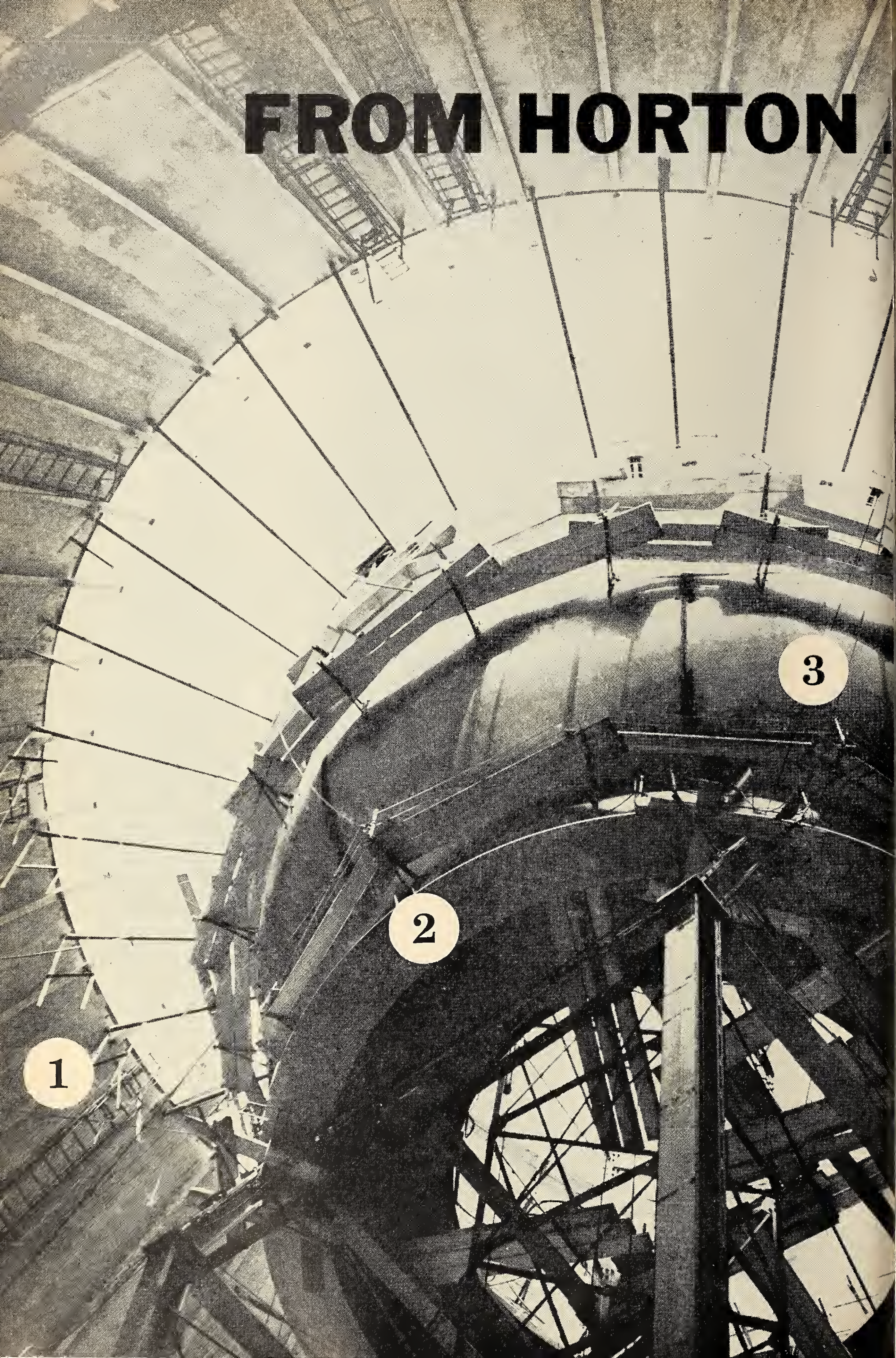
The physical processes of major importance in the design of sanitary engineering treatment facilities are discussed with emphasis on the rational rather than the empirical approach to design problems. The author covers fluid transport in closed and open conduits, mixing, sedimentation, floration and aerosol separation, flow through beds of solids, vacuum filtration, gas transfer, adsorption and leaching, heat transfer, evaporation, psychometry and humidification, and drying. (L. G. Rich. New York, Wiley, 1961. 308p., $10.75.)

°OPTIMUM USE OF ENGINEERING TALENT.

Various phases of effective engineering management are discussed, from the basic objectives, responsibilities, and organization of the engineering division to the recruiting and selection, compensation, supervision, professional development, and evaluation of engineers. A special group of case studies describes the engineering organizations of *IBM*, *Carborundum* and *Convair*. (Ed. by J. W. Blood. New York, American Management Association, 1961. 416p., $9.00.)

(Continued on page 114)

FROM HORTON .



• Discussion

(Continued from page 68)

power system, is not sufficient to provide complete stabilization with permanent speed droops which are usually in the order of 5%. When a power system is operated in the manner described above, it is usual to place the dashpot by-passes in operation on mechanical type governors and operate with a very minimum of secondary compensation. This practice may be quite feasible on a moderate sized hydro system when it is tied in with a large system. However, if this system ever becomes detached from the large one, instability can result. Another hazard that is involved with major hydro systems which are interconnected with each other is that each system may assume that it is a small system relative to the whole, and by reducing the secondary compensation, endanger the whole interconnection from a speed stability point of view. In other words, if all the hydro systems which are interconnected with each other, adopt this same practice, then the whole system considered as a large equivalent generator could go into a continual hunt as regards frequency.

On the system with which the writer is associated, only the machines which are controlling the generation for load frequency control purposes have the secondary compensation reduced by using the mechanical by-pass and all other machines are left with normal primary and secondary compensation settings.

In connection with the author's remarks on the effects of water inertia, he states that the effect of gate closure and gate opening causes unstabilizing factors which are "quickly arrested". It should perhaps be pointed out that on one hydro generating station which is being constructed by the writer's organization, mathematical computation indicates that on a gate closure the component of turbine torque, due to the water hammer effect, persists for about 10 seconds in a positive direction and the peak value of this change does not appear until about five seconds. These times are measured from the instant of gate closure. This relatively long time is due to the fact that the water starting time on this particular machine is in the order of 2.5 seconds.

The author mentions that the setting of hydro governors for stable operation are made in accordance with the requirements as indicated in References 4 and 5 of the paper, namely:

$$= 2Tw, \quad Tr = 5\ Tw.$$
$$\overline{\quad Tm \quad}$$

He states that the machines are set up to these values for off-line operation although the parameters indicated are those shown for full load on line operation if rated water velocity for full load operation is assumed in the calculation of Tw. It perhaps should be pointed out that if Tw is calculated for a water velocity corresponding to off-line operation in setting up the governor, then a low value of Tw will result and while the machine perhaps would be stable at speed no load, it could be quite unstable at full load due to the fact that Tw is much higher under rated load conditions. It is the writer's opinion that the values shown in Fig. 4 should be stated as those corresponding to full rated head and load in order that an adequate margin of stability be retained on the machine under all conditions.

The writer agrees entirely with the author's remarks with regard to the sluggish response of mechanical type governors when the secondary compensation is not reduced for on load operation. However, the writer feels that the approach to obtaining faster response by using the dashpot by-pass valves should be approached with caution, particularly if it is decided that all plants on the system are to be set up with these devices in operation, and as mentioned previously, in the writer's organization these devices are only used on the machines which are required for load frequency tie-line control.

In Fig. 3 on Page 4 an excellent diagram is shown giving the relation between isochronous and permanent speed droop operation of say two machines. However, for purposes of accuracy, would it not have been better to have used the term "gate" instead of "load" in order to accord with the definition of speed droop which relates speed to gate position rather than load.

The writer is happy to note the author's remarks with respect to electro-hydraulic governors and the advantages they possess over the mechanical type governor with which most of us are familiar, and it might be of interest to point out the writer's organization is now building a large hydro station which in all likelihood will be fitted with electro-hydraulic governors using derivative stabilization. It is felt that this form of governor will provide considerable advantage in that load frequency control will be transferred to these machines, probably with joint control facilities and the stepped permanent speed droop characteristic which is shown in Fig. 11. The writer feels that the derivative stabilized governor has a distinct advantage over the temporary droop type governor in that no change has to be made to the stabilizing circuits after the machine becomes connected to the system, such as is required with a conventional type governor which received its stabilizing signals from gate movement. In connection with the stepped permanent droop characteristics which the author points out as being provided in a large hydro-electric generating station presently under construction, the writer would like to inquire as to what range is being provided for the deadband zone.

In commenting on the author's conclusion, the writer agrees wholeheartedly that some form of central authority may be necessary when interconnection expand into the future in order that the participating power systems may co-ordinate their control systems to obtain mutual benefit and satisfactory operation of the whole interconnection.

Discussion by
C. Kent Duff

The major conclusion of this paper (p. 13) is that electro-hydraulic governors should be adopted, especially where the generating stations will be under automatic load-frequency control. The potential advantages of electric governors appear to justify this conclusion as a long-range goal.

Ontario Hydro has begun to move in this direction but experience to date is limited. A demonstration-type electric governor was tried at DeCew Falls plant for about 10 months in 1958-59. This governor had temporary droop stabilization and worked satisfactorily in normal operation and also for brief periods on load-frequency control from a remote point.

We now have in commercial operation two permanent installations on the two 20.25 Mw. units at Red Rock generating station in Northeastern Ontario. These units have fixed-blade propeller turbines operating under a net head of 93 ft. The governors are twin-cabinet actuators with electrical speed sensing and speed-derivative stabilization. These governors have operated satisfactorily for wide changes in the amount of interconnected generating capacity, including the condition of isolated operation, without alteration of the stabilization settings. The first unit was commissioned in the fall of 1960 and the second in January 1961. These units have not been used for automatic load-frequency control but experience to date supports the expectation that they would perform well in that service.

We have also added a rapid load control auxiliary ("transducer", p. 12) to the cabinet-type mechanical governors in several existing plants after trial installation on a unit at Sir Adam Beck — Niagara No. 2 generating station in 1957. This device has some of the important advantages of an electric governor in that it is adapted to receive a continuous type control signal (d-c milliamperes) and can quickly position the governor speed setting to a corresponding level. It can also maintain approximate load balance among the units in one plant. The governors are also equipped with a solenoid-operated dashpot by-pass, open continuously when the unit is on automatic load-frequency control to reduce the governor response time.

Certain statements or recommendations made by the author may be debatable, and on some of these the following comments are offered.

1. The statement on page 2 — "The isochronous governor is inherently unstable", may be misunderstood if read out of the context of paragraph (a) which indicates that means of stabilization must be (and normally are) built into the governor.

References to hunting or oscillating of two or more units controlled by isochronous governors (p.2), and to two or more stations controlled by flat frequency controllers (p.5) give an unrealistic description of their interaction. Rather, the load will drift, more or less gradually, from the unit having the lower speed setting to the one having the higher speed setting, until one or other reaches the limit of its gate travel.

2. Permanent speed droop is the relationship between steady-state speed and gate opening, and is so described in the first paragraph of section (c) on page 2. A more specific definition is given in section 14 of AIEE Standard No. 605, September 1950, "Recommended Specification for Speed-Governing of Hydraulic Turbines Intended to Drive Electric Generators". In Fig. 3, permanent speed droop is erroneously described as the per unit change of frequency corresponding to a load change from zero to "full load". The relationship between steady-state speed and load is known as "steady-state speed regulation", as defined in section 15 of AIEE Standard No. 605. Speed regulation is always less than speed droop, usually between 65 and 90% of the speed droop. Unlike speed droop which is determined only by mechanical settings in the governor, speed regulation varies with changes in head on the turbine. Also, the speed-droop curve is usually close to a straight line, whereas the speed regulation curve is affected by non-linearity in the load-gate relationship. The incremental speed regulation, therefore, may vary greatly over the load range.

(Continued on page 103)

In general discussions on frequency con-
rol and load-sharing among units, the term peed droop is often loosely used to mean peed regulation. The distinction should, owever, be recognized in cases where the ifference is significant.

3. In sub-section (f) on compensation, age 3, it is stated that — "This anticipa-ory action must be a function of the cceleration of the unit . . . ". This state-ient is inconsistent with subsequent state-ients on the same page, wherein gate osition feedback (temporary droop sta-ilization) is mentioned as a form of antici-atory action.

Temporary droop stabilization is said to e "the derivative of the gate movement gate acceleration) —". The writer suggests hat gate speed rather than gate accelera-ion is the true basis of temporary droop tabilization.

4. Excessive wear of parts of governors nd associated equipment is usually ex-ected when automatic load-frequency con-rol is applied to generating units. (See ages 5 and 8). In the experience of Ontario Hydro over a period of 26 years, ising impulse-type reset control (short, in-ermittent raising or lowering impulses to overnor synchronizing motors) increased vear has not been noticeable. More re-ently, however, continuous type control of ynchronizing motors using thyratons has ncreased the maintenance on synchroniz-ng motors in one plant. The addition of apid load-control auxiliaries for the gover-ors of this plant is under consideration.

In special tests where a single large unit as been forced to take all the swings with igh-speed continuous-type control, gover-ior oil-pump motors tended to overheat nd the turbine gate stems required more requent lubrication, but this was not a ormal condition.

5. The author advocates (page 12) the se of solid-state devices in system control quipment to reduce time lags, etc. These levices, when operated within their limits f current, voltage and ambient tempera-ure, do have a number of advantages. It hould be noted, however, that they are ery easily damaged by inadvertent ap-lication of excess voltage which may occur uring routine testing or from voltage urges in the power supply. Maintenance ersonnel require special training in test rocedures on transistorized equipment. ransistor burnouts have also been at-ibuted to voltage surges in the d-c power upply from a station battery. Filter net-vorks and zener diodes have been used for rotection against damaging over-voltages.

6. In the section on Operating Problems nd Requirements, reference is made to everal kinds of interactions and means for voiding them. It may be added that the nteractions between a station on Flat Fre-uency Control and another station on lat Station Load Control (p. 9) will occur lso on interconnected systems where one stem is on Flat Frequency Control and thers are on Flat Tie Line Control (p. 6). he solution is to put all systems on tie-line ias Control as advocated on p. 6, with he bias setting of each system controller et to match the natural droop of each ndividual system.

Interaction between stations having dif-erent rates of response to a common reset ontrol signal is explained on p. 10 and is shown that the rate of reset should ot exceed the response rate of the slowest ation. It does not follow, however, that he response of all systems in an inter-onnection must be reduced to the rate f the slowest, because each system is regulated by its own controller which can be matched to the response of its own generation. A slow-responding system in an interconnection merely prolongs the time during which other systems must lend temporary support following a disturbance originating in the slow system. If the disturbance occurs in the fast-responding system, the correction will be made more quickly. Cf. First paragraph in sub-section (c), page 11.

7. This final comment relates to the startling proposal to make governors insensitive to frequency and dependent only on control from a system controller. This radical doctrine is stated in sub-section (d), page 5; in sub-section (f), page 8; in sub-section (b), page 11; and is finally proposed on page 12 in the form of a compromise, "Stepped Permanent Speed Droop Characteristic". This proposal and its implications require a much more thorough examination than they have received in the paper. This discussion will merely list a few salient questions and offer some tentative answers.

(a) What more intelligent command can be given to a governor on the occurrence of a frequency change than to change load by a proportionate amount, at least as an initial action?

(b) What system controller could produce frequency-corrective action more quickly or reliably than the governor itself can do when permitted to respond to its own frequency-sensitive element?

(c) If many units on the system have Stepped Droop governors, not intended to change load for frequency changes within a given band, what kind of frequency fluctuations may be expected, and what will be the load swings on the remaining governors which are frequency-sensitive?

(d) How will the conventional Tie Line Bias Control behave on a system having an appreciable proportion of Stepped Droop governors insensitive to frequency in one band but fully sensitive outside that band?

The writer's preliminary analysis of these questions leads him to the conclusion that the removal or limitation of the governor's speed-sensitive characteristic is a move in the wrong direction. Service security as well as service quality (frequency) demand sensitive, accurate and quick-acting speed governors responsive to frequency changes small or large. These characteristics are among the principal ones advanced in favour of electric governors. No governor can react more quickly and reliably to remote control than it can react to its own built-in speed-sensing elements which measure speed at the generator and not at some remote point which may be at a different frequency during emergencies. Conventional Tie Line Bias control, which is predicated upon a relatively constant load-frequency characteristic of the system, will not be able to match a characteristic which changes drastically at the break points of the Stepped Droop curve. System frequency fluctuations will be greater, and larger load swings will be imposed on units having conventional speed-droop governors. If these conclusions are correct, the proposal requires re-thinking in the light of the "Common Welfare" philosophy so properly commended on page 10.

Discussion by
G. H. Dunn

I question Mr. Long's statements, in two sections, that the use of speed derivative stabilization in an electro-hydraulic governor offers an advantage over temporary speed droop stabilization because the fastest possible response is always obtained without any change in the stabilization arrangement. Mathematical studies have been presented in many technical papers which show that the response of both types of governors to system frequency changes can be represented by similar equations. This fact was established as early as 1947 in the following:

"Drehzahlregelung der Wasserturbinen"
by T. Stein
Schweizerische Bauzeitung
1947—Vol. 65—p. 531

A simplified mathematical development, using certain assumptions generally recognized as being valid, gives the following:

For the temporary speed droop governor

$$\frac{\sigma}{f} = \frac{Ko}{S} L \frac{1 + STi}{1 + LSTi} \qquad (1)$$

where σ = gate position deviation (relative value)
f = frequency deviation (relative value)
Ko = forward amplification of governor
S = Laplace operator
Ti = temporary droop time constant

$$L = \frac{1}{1 + Ko\delta_t Ti}$$

where δ_t = temporary droop strength

For the speed derivative governor

$$\frac{\sigma}{f} = \frac{Kacc}{S} \times \frac{1 + S\chi Tacc}{1 + S\,Tacc} \qquad (2)$$

where $Kacc$ = forward amplification of governor
$Tacc$ = time constant of derivative scheme
$\chi = 1 + \beta$
where β is the strength of the speed derivative signal.

Let us assume that Ti and δ_t are set such that the following relationships are obtained (as Mr. Long points out, these values are easily adjusted on the temporary speed droop governor):

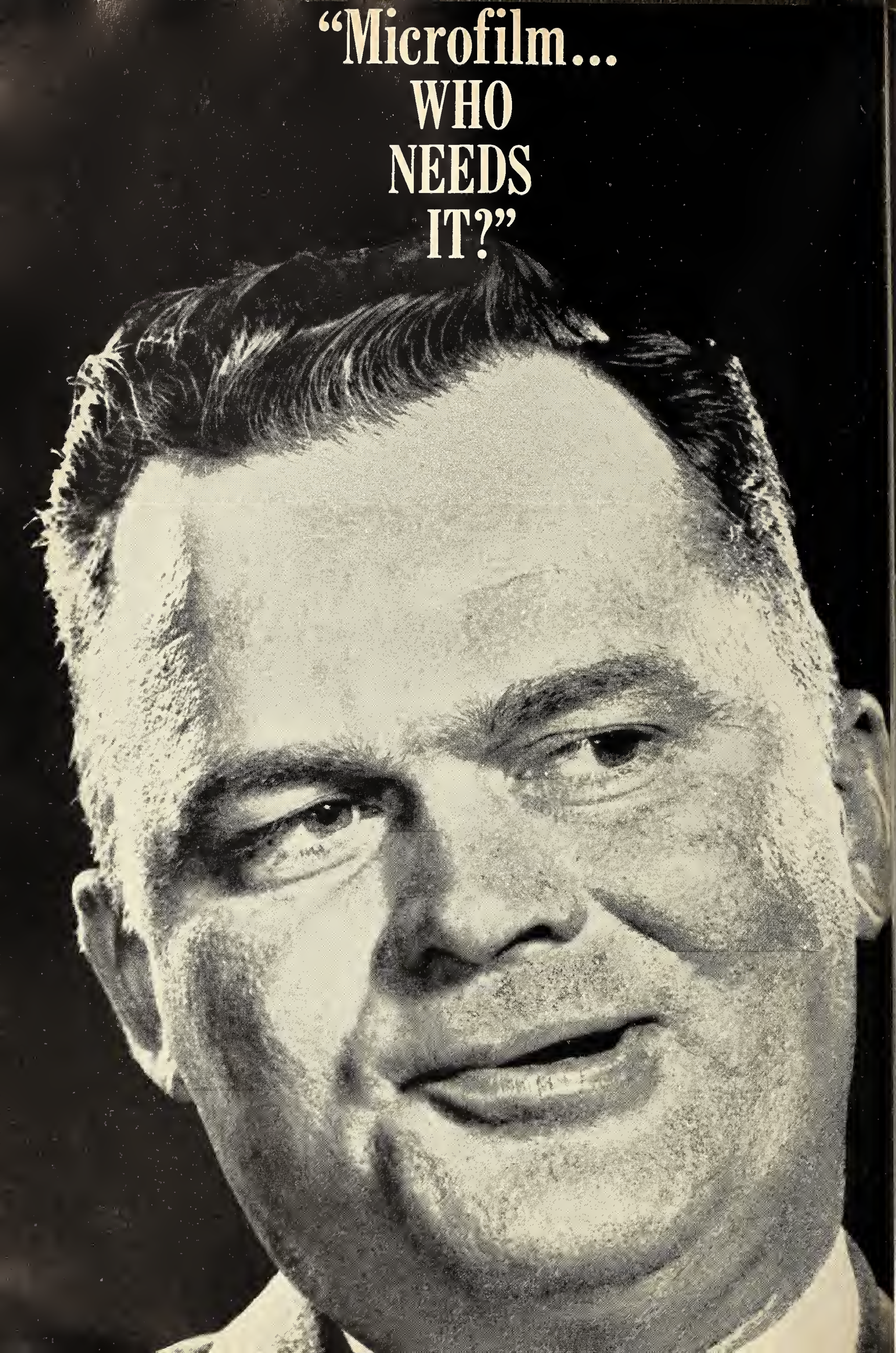
$$KoL = Kacc$$
$$TiL = Tacc$$
$$\frac{1}{L} = \chi$$

The two equations then become identical and both governors would have exactly the same response to system frequency changes. It is obvious that if Ti and δ_1 are now changed again to give a faster response for a frequency change of the same nature, there must be a change in one of the parameters used for the speed derivative governor if it is to have an equal speed of response.

Such changes are usually more difficult to make on speed derivative governors than on temporary speed droop governors and must often be accompanied by a change of the rate of response of the servomotors for reasons that will be explained in the following.

While the nature of response to frequency changes of both forms of governor is very much the same, the mode of operation is, of course, quite different. The distributing valve in a speed derivative governor quickly reaches a larger displacement for a given frequency change than is the case with a temporary speed droop governor but the servomotor used in connection with the former must, of necessity, have a slower rate of movement (other factors being the same) and, in effect, has an integrating

(Continued on page 108)


"Microfilm...
WHO
NEEDS
IT?"

(Continued from page 103)

action in contrast to the proportional action of the servomotor with the distributing valve in a temporary speed droop governor. In part (c) of the final section in Mr. Long's paper, it is implied that for both types of governors the distributing valve has a proportional action while the servomotor has an integral action. This is not the case, as indicated above, but it is true that both governing systems have an integrating stage as well as a proportional response stage such that there is a proportional-integral action for both, as mentioned in the paper, and the same type of response to system frequency changes for both.

When performing output adjustments on a unit under load, either manually or by load control signals, the above-mentioned difference in servomotor speed would, of course, result in a slow steady change on a speed derivative governor in comparison with the quick initial movement, and subsequent settling, obtained with a temporary speed droop governor. When considering the load-frequency control requirements outlined by Mr. Long, it would seem that a governor with temporary speed droop stabilization, with its faster initial response to control signals, would have an important advantage over a governor with speed derivative stabilization.

The author has detailed many of the advantages of electro-hydraulic governors over mechanical-hydraulic governors. Even when considering only the regulation capabilities demanded by load-frequency control schemes, one could add to his impressive list the advantage offered, in the use of ASEA electro-hydraulic governors at least, by the compensation possibilities for load-gate curvature, in the load sensing circuitry, such that the output response for a control signal is always the megawatt value desired regardless of gate position. For mechanical-hydraulic governors, control signals are usually applied to a motor drive on the control linkage and although a gate position switch, or switches, can be used to alter the motor speed as the output response per unit of gate travel changes, this system can never provide response to signals, over the complete range of gate travel, that is satisfactorily uniform. Other difficulties in obtaining proportionality of response to control signals when using a motor actuated control linkage, arise from the unavoidable start-up time, overtravel, etc. When using electro-hydraulic governors the control signals can, of course, be introduced directly into the control circuits.

In connection with the joint control feature of electro-hydraulic governor circuitry, other points of interest, not mentioned by Mr. Long, include the following:

a) should one of the units under joint control be lost or reject load for any reason, the other units will automatically increase their outputs in an attempt to restore the station output to the set value and will, therefore, minimize the system disturbance.

b) if the generating units to be operated under joint control are not all of the same type, the load division scheme can be adjusted to ensure that this combination of units will always operate at the highest efficiency possible for the instantaneous value of output. This predetermined distribution of loading for efficiency purposes is maintained even for isochronous operation of one or all of the units.

While Mr. Long has stated that the versatility of the electro-hydraulic governor can be of particular advantage in individual power systems where proper co-ordination of operating characteristics of various units and stations can eliminate the need for any auxiliary load-frequency control equipment, I might mention that the versatility advantage extends into fields other than load-frequency control of systems. Since electrical control signals can be applied directly to the control circuitry without the use of intermediate electrical-mechanical devices, it is quite simple to arrange governor response to any variable that can be represented by an electrical signal. One example of such variables would be forebay water level. Direct proportional response or response biased by other regulation requirements can be used.

The author has indicated that the initial amplification stage in electro-hydraulic governors is usually in the form of magnetic amplifiers. While several of the manufacturers who have just recently developed and introduced such units, are using magnetic amplifiers, I believe that the great majority of electro-hydraulic governors that are presently in use have electronic preamplifiers. The author's recommendation for widespread adoption of electro-hydraulic governors is undoubtedly based upon operating experience with electronic preamplifier governors which has been reported to be entirely satisfactory in every respect.

It is, of course, desirable to adopt solid state techniques as the author suggests, where such equipment has definite advantages over the equipment that has been used in the past. In many cases, however, investigations have proven that no advantage is to be gained, and difficulties can arise if these techniques are prematurely adopted for certain items.

The author's recommendation that a discontinuous stepped permanent speed droop characteristic be instituted as a special feature of electro-hydraulic governors that are to respond to automatic load-frequency control, ignores the fact that at least one type of electro-hydraulic governor, the ASEA governor that has been in service for 17 years, has a master permanent speed droop control for all units under joint control. Thus, the unit and station frequency bias can be set to a value that will eliminate any interaction between governors and the load-frequency control equipment and, in this way, the need for the special characteristic (which has some undesirable features) is avoided.

Discussion by
C. L. Avery

This discussion is concerned with certain portions of the paper which discuss turbine governors and their operation.

While they are used on some types of governors (diesel, aircraft, etc.) it is not standard practice to use non-linear speeder springs on hydraulic turbine governors. The range of speed control is so limited, that a linear load-deflection spring characteristic matches the centrifugal force characteristic with sufficient accuracy.

Provided that optimum compensation settings were used, hunting, strictly speaking, would not occur between two units operating isochronously. There would, however, be a transfer of load between units which would cause one or the other to carry more than its share of the load changes and nullify the effectiveness of the control.

We would question that even on slow or gradual load and frequency changes, except in the case of thermal units, the self-regulation and permanent speed droop are adequate for stability. A reduction in compensation can be made by virtue of the self-regulation of a comparatively large and well diversified connected system. However, if all compensation except permanent speed droop were nullified on all the generating units, a predominantly hydro system would become unstable.

It is well to consider the reason behind use of the dashpot by-pass which is one means of nullifying the effect of compensation. The dashpot by-pass is used for the sole purpose of improving the response of the governor to external adjustment. Its use has a detrimental effect on system stability. Incipient system instability develops when too many units on a system are operated with open dashpot by-passes. Lately, therefore, it has been recommended that only the units which are under active automatic load-frequency control be operated with the by-passes open and that the base load plants operate with normal compensation at some sacrifice of ease of control.

In the case where the automatically controlled plant represents a large portion of the generating capacity, it may not be possible to reduce compensation at all when on the line, and a satisfactory adjustment of the controller for a slower acting governor must then be made.

The sources of inaccuracy of the governing system lie chiefly in hydraulic and turbine control mechanisms. Since these same elements are used in both the electric and the mechanical types, the initial accuracy of the governing system is substantially the same for either type of machine. It is possible that the electric governor will maintain this degree of accuracy for a longer period.

The time lags in modern hydraulic governors have been reduced to minimum values. The principal time lags encountered are those required for stability of operation which must, after all, be tolerated.

The principal advantage of the electric governor is its acceptance of a continuous control signal (as for fringe load control). The application of the speed-setting transducer to new and existing mechanical governors makes them equivalent to the electric governor in this respect. The speed adjusting transducer also provides means for applying joint load control to mechanical governors. During the past three years, some 60 of these devices have been furnished or are on order for various North American installations.

With either an electric or mechanical governor with speed-setting transducer operating on fast or fringe load control, greater activity of the governing system and turbine gate is to be expected. The turbine control mechanism and the governor oil supply system should be designed for this condition. Ample oil pump and oil tank capacity are required, and automatic lubrication of the gates is usually indicated.

Discussion by
J. M. Logan

Interconnections between power systems will continue to increase. The author points out that coast to coast and continent-wide interconnections will be realized very soon. This, we feel, is a very accurate statement of fact.

As each new tie is closed, one becomes aware that a new, more challenging, perhaps more difficult engineering problem emerges. The use of computers will result in greater economy in the operation of interconnected systems. The computer will insert its own characteristics into each system being installed.

(Continued on page 110)

(Continued from page 108)

A basic, present day, understanding is necessary before one can build the future. In this excellent paper one can find what makes up our present day understanding of the nature of the load control problems of interconnected power systems.

Author's Reply

The author feels deeply indebted to the number of discussers who have given so much of their time, effort and talent in preparing such cogent remarks in their discussions, which have enhanced and contributed significantly to the value of this paper. The subject matter is rather complex and covers a very wide scope embracing several specialized fields in which the author is associated. It is impossible to cover exhaustively all areas in these fields due to the limitation set for the length of paper. The discussions presented serve extremely well in supplementing and elaborating on many aspects of the paper. Certain points raised by several discussers will be commented on only once in the order in which they initially arise. On the other hand, some comments made by one discusser are complemented, supported or contradicted by those made by others; these comments are left to the reader to ponder.

Nathan Cohn:

The favorable comments by Mr. Cohn, who is an eminent authority on the subject of generation control of power systems, are indeed very heartening. He has elaborated and emphasized three important areas of the paper to bring into clearer focus the problems associated with power systems regulation. For deeper insight into the matter of generation control, it is recommended that Mr. Cohn's many papers be read.

N. P. Percival:

The need to distinguish between the instability of the power system and that of the control system has been very appropriately brought out by Mr. Percival. He has also pointed out various considerations influencing the stability of the control system. The comments on his experience of gain adjustment of the telemeter channel or the governor merit particular attention and study. Mr. Percival's reference to the combination of gate dashpot effect with accelerometer effect to improve response and stability of the governor is a worthy consideration which the author has raised in discussions with others in the governor field, especially in connection with load-frequency control of interconnected power systems.

L. M. Hovey:

The author has generalized in a number of statements made throughout the paper. This applies to the statement that the effects of self-regulation and permanent speed droop are usually adequate for steady state stabilization which may apply to prime movers in general. Mr. Hovey's qualifying statements in this regard as applied to predominantly hydro systems are well taken.

The caution which Mr. Hovey urges with respect to the reduction of secondary compensation by opening the dashpot by-passes on mechanical governors deserves considerable attention. The policy adopted by Mr. Hovey's organization of reducing the secondary compensation for only those machines under load-frequency control is certainly a logical approach towards attaining system stability. Even for such a policy, it is well to exercise some of this caution urged by Mr. Hoveys, as indiscriminate reduction of secondary compensation for these machines would result in their interaction with the load-frequency control. Moreover, such a policy may not be too practical for power systems without proper facilities provided for their governors. For instance, on power systems where the load-frequency control duties are transferred from station to station as determined by system operating conditions, and where the mechanical governors are not provided with solenoid operated auxiliary by-passes, this policy would burden the powerhouse operators with additional duties to put into or take out of service, accordingly, the mechanical by-passes on the affected units. This procedure is extremely cumbersome and normally is not the responsibility of the operators. Furthermore, such a policy imposes upon the stations not under load-frequency control with sluggishly responding governors; these stations are still subject to changing their output from time to time as instructed from the system office.

Other than the installation of electric governors throughout the system, the author contends that the most satisfactory arrangement would be a compromise setting of the by-pass openings to provide reasonably good response of the on-load units consistent with good stability of the system. This arrangement would require the close collaboration of the utility's governor and load-frequency control personnel in co-ordinating and tuning the governor adjustments with that of the load-frequency control from time to time under a well planned, regularly scheduled, test and maintenance program.

Mr. Hovey's comments on the effect of water inertia, with the example given, serve to illustrate exceptions to the generalized statement made by the author.

Due to space restrictions, the complete explanation of the denotations shown in Fig. 4 was not given, as it was assumed that those familiar with the expression knew that full rated head, load, and velocity at rated speed were involved, and that those unfamiliar would become acquainted with these terms by referring to appropriate sources. If other readers misinterpret the author's meaning as outlined by Mr. Hovey, this point should be clarified by his remarks.

The author is aware of Mr. Hovey's finer distinction in the use of gate position, rather than load, for the definition of speed droop, as evidenced by the definition given in the paper. In a paper restricted to a rigorous development related to turbine governors only, such accuracy would be appropriate. Again, due to space restrictions, it was expedient for the author to resort to the use of Fig. 4 to illustrate an important point regarding the interaction between the governors and the load-frequency control.

The range being provided for the load control zone of the stepped permanent droop characteristic of the large hydro-electric generation station referred to in the paper is from zero to $\pm$ 0.5 cps, that is, a bandwidth from zero to 1 cps.

C. Kent Duff:

The initial portion of Mr. Duff's discussion relating his experience and views is very informative. The remainder of his discussion, however, deals primarily with certain aspects of turbine speed governors and are, in the author's opinion, inconsequential to the understanding of the overall step-by-step development of the paper.

With reference to the performance of two or more units on isochronous governor operation (or of two or more stations — or systems — on flat frequency control) the load transfer from the units having the lower speed settings to those having the higher speed settings would not merely drift, but would be transferred as quickly as the various equipment and system conditions would permit. If the speed settings of the units were exactly coincidental, however, a resonant condition would exist and the inevitable result, as with any resonant condition, would be oscillation or hunting among the units. This is the condition referred to in the text of the paper.

With regard to the interaction of interconnected power systems on tie line bias control, this difficulty is experienced on several power pools both on this continent as well as in Europe. Perhaps a simple mechanical analogy would more clearly elucidate the basic concept of the interaction which will result from interconnected power systems having different speeds of response. Visualize two transport trucks interconnected by a tie line consisting of a heavy spring with the tension and speed to be maintained at specified values. These values would be indicated instantaneously to each driver by appropriate gauges and speedometers. Assume that the load on either vehicle is varied by the application and releasing of brakes independently controlled from the drivers. If load is suddenly applied on only one vehicle, momentary assistance would be given by the other vehicle while the speed and tension common to both vehicles would be affected accordingly. To bring the speed and tension back to their specified values, the driver of the vehicle with the applied load will strive to increase its output as soon as possible, while the driver of the other vehicle will strive to decrease its output to maintain the specified tension, tempered by a slight tendency to increase its output to maintain the specified speed. If the speed of response of both drivers are not co-ordinated in their efforts, with one driver having a fast response while the other driver has a slow response, the result will be wide swings in the common spring tension from the specified value in a manner similar to that shown in Fig. 10 with the swings eventually becoming quiescent at the specified tension. The variation in the common speed would behave in a corresponding manner but would be less striking. If the analogy is compounded by continuous load changes, the interaction would be perpetuated indefinitely. If the analogy is compounded still further by interconnecting additional transport trucks in tandem, polygon, or star, each with its own continuous load changes and each driver with his own speed of response, the situation then becomes extremely difficult and complex. Under these conditions, it would be impossible to maintain the complex interconnection for any length of time, and the ultimate result would be a separation of the interconnection into simple isolated interconnections.

While Mr. Duff regards the proposal of the stepped permanent speed droop characteristic as being a radical doctrine, there is evidence that this proposal has been independently arrived at, advocated, and put into operation by others in certain European countries. (Reference: Discussion by Mr. Raeber in "Bulletin", paper of the Swiss Electrical Society, April 22, 1961 issue).

For individual isolated power systems, the frequency is the only criterion required to gauge the quality and status of generation regulation. For tie line bias control of

(Continued on page 112)


150
100
200
50
250
LBS.
INCH
300
0
MORRISON BRASS
PRESSURE
VACUUM
ALTITUDE
OXYGEN
COMPOUND
HYDRAULIC
SPRINKLER
LOCOMOTIVE
COMBINATION
DUPLEX
AMMONIA
ILLUMINATED DIAL
ELECTRIC ALARM
LABORATORY TEST
INSPECTOR'S TEST
MB
MORRISON'S
the name for
GAUGES . . .
Since 1864, Canada's most dependable gauge maker . . . manufacturing every type of gauge, for every known application.
NEW EQUIPMENT GIVES FAST, FAST SERVICE!
We have now installed the most modern precision equipment yet introduced. This permits us to manufacture all gauges in Canada . . . and give better-than-ever faster-than-ever, gauge deliveries.
"Call Morrison Brass!"...whenever you need fast, dependable, same-day delivery or repair service on gauges.
...IN ALL CANADA!
Buy Morrison Canadian-made Gauges
Phone or write for our complete catalogue
Distributors from Coast to Coast
THE JAMES MORRISON BRASS MFG. CO. LIMITED
276 King St. West, Toronto
Phone EM 4-3213

(Continued from page 110)

interconnected power systems, frequency is only one of two variables that must be maintained closely to prescribed values. As relatively constant frequency is an inherent product of large power pool operation, which "conventional tie line bias control is predicated upon", it is evident that the power transfers over the tie lines are at least equally as important as the system frequency for interconnected power systems operation. Hence, to reduce the interaction of one control entity with the other, the entity with less intelligence should be made subservient to the other. While the speed governor has only the intelligence of receiving the value of the actual speed and comparing it with a speed reference to detect the error and moving the wicket gates accordingly, the tie line bias controller receives a host of information, including the prime requisites of system speed and tie line flow, with which to compute and dispatch automatically the proper control signals to regulate the generation desired for the power system; consequently, the controller would be in a much more favourable position to be co-ordinated in its action with that of the central controllers of other participating power systems than the individual speed governors for the common welfare of the interconnection. Mr. Cohn's discussion elaborates more fully on the many considerations of multiple-area interconnections. Therefore, the desirable qualities of sensitivity, accuracy, and quick action of electric governors should not be confined to speed reference only, but should also apply to load reference, especially for tie line bias control operation.

The situation of different frequencies during emergencies on a power system can only occur in the event of the separation of the system into localized areas. Proper system planning of the centralized automatic load-frequency control should provide adequate protection facilities for such emergencies which will trip-free each individual governor to function in accordance with its individual conventional speed droop characteristic while simultaneously locking out the control system. This arrangement would thus prevent the situation from being aggravated by the undesirable continued functioning of the control system.

The conventional tie line bias control would not have any more difficulty "to match a characteristic which changes drastically at the break points of the Stepped Droop curve" than it would have with the conventional speed droop curve with dead band (Fig. 11). In both cases, as the frequency moves beyond the respective bandwidth, the governor will function to actuate the wicket gates in the appropriate direction and the gates will assume a position in accordance with the droop characteristic. The main difference would be that, with the frequency staying within the bandwidth, the governor with the conventional speed droop dead band would allow the wicket gate position to drift from one extremity to the other within the cross hatched area in Fig. 11, while the governor with the stepped droop characteristic would not be allowed to drift but would follow the external load control setting diligently and precisely. The author, therefore, disagrees with the conclusions that greater system frequency fluctuations and larger load swings can be expected as a result of the application of the stepped droop characteristic to stations under tie line bias control.

G. H. Dunn:

While Mr. Dunn's reference to the studies by T. Stein — showing the response to system frequency changes of the speed derivative and temporary droop governors to be very much the same — is very interesting, the mathematical development presented is irrelevant to the response of these governors to external adjustments. It should be pointed out, moreover, that the author had no intention of showing preference for one over the other, but merely wished to outline the two methods of stabilization of governors.

With regard to the issue as to the sequence of proportional or integral action of the distributing valve versus the servomotor for either the derivative or temporary droop governors, the order as to which action precedes the other hardly matters in the general development of the paper in relating these two types of action as being desirable qualities for both the governor and load-frequency control. Perhaps the author should have placed more emphasis on the suggestion that the derivative of area requirement, or the measure of the rate of change of area requirement, be incorporated as an automatic means of regulating for the optimum dynamic response of the centralized automatic load-frequency control system. This quality was inadvertently introduced as a by-product of a modification made on the control system which the author is associated with and it was found to improve the performance of the control system considerably.

The finer details of electro-hydraulic governors outlined by Mr. Dunn as additional advantages are appreciated.

As to the relative number of electric governors with magnetic amplifiers versus electronic amplifiers, to the author's knowledge there are more manufacturers utilizing the former than the latter in recent designs. The author had no intention of showing favoritism for one over the other but merely wished to outline the two types available.

The feature of the master permanent speed droop setter was not ignored but was stated as one of the features of joint control. While this feature is convenient, its use will not eliminate the interaction between the load-frequency control and the governors. It is the load-frequency control that must be biased by the correct degree of frequency error or the use of a strictly load sensing governor if interaction is to be eliminated.

C. L. Avery:

The qualifying statements made by Mr. Avery on non-linear speeder springs; optimum compensation settings as a provision to prevent hunting of isochronous units; relative influence of self-regulation with permanent speed droop for thermal and hydro systems; relative accuracy of electric versus mechanical governors; the speed-setting transducer for mechanical governors; and further considerations of importance to the governing system operating on fringe control, are much appreciated. As Mr. Avery is a distinguished authority in the governor field with an impressive record of practical experience, his comments are considered a valuable contribution to the paper.

J. M. Logan:

The author has had the pleasure of working closely with Mr. Logan in the specification, installation, trouble shooting and final commissioning of the centralized automatic load-frequency control system of the power network with which the author is associated. Mr. Logan's comments are much appreciated.

• Developments

(Continued from page 84)

THERMOVOLT LIMITED, has announced the acquisition of Transformer Electronics Limited, a Toronto firm producing military specialty transformers, magnetic amplifiers and relays. The company also announced that it had added 7000 square feet to its facilities.

DIRECTORS of the 1962 Seattle World's Fair opening April 21, have announced that International Business Machines will soon begin construction of a display pavilion. The display will be called "New Paths to Knowledge", and will show in non-technical terms how the modern tools of computers are used to build new and wider paths to greater knowledge.

CONSTRUCTION has started on the 1,000 foot long overpass in the city of Medicine Hat, Alta. to grade separate on of the City's main thoroughfares, Allowance Ave., with the mainline of the Canadian Pacific Railway Company. The overpass features prestressed concrete design with girders from 90 to 100 feet in length. Continuity over the piers has been introduced by means of specially designed reinforcing steel deck slab.

THE TRIMPOT DIVISION of Bourns Incorporated has announced the availability of the Model 3368, a subminiature single turn rotary potentiometer designed for use in printed circuits and other modular type applications where extreme angular resolution is not required.

A PLASTIC sealing machine developed for high-speed sealing of blister packages will be marketed by United National Sales Organization. The Clear-Pak Jr., is a low-cost, power operated machine that is capable of making one seal every three seconds.

CAPITAL CONTROLS has announced a dual gas chlorinator, which handles all dual installations from one chlorinator. Pre and post chlorination at any two points of application once handled by two units or costly solution panels can now be handled by one unit mounted directly on the one gas cylinder.

CANADIAN KODAK has introduced a new industrial x-ray film. The emulsion is an improved Kodak Industrial X-ray film, Type F, whose speed has been increased by 30 to 50%. Designed for use with industrial fluorescent screens, the improved film is specially adapted to industrial radiographic exposures where the thickness of the specimen slightly exceeds the capacity of radiographic equipment to make direct or lead screen exposures. Other advantages of the film are its higher contrast, and the fact that it can be processed by the Kodak X-Omat System, which delivers fully processed and dried radiographs in a matter of minutes.

(Continued on page 116)

• Library Notes

(Continued from page 93)

*NATIONAL SYMPOSIUM ON MACHINE TRANSLATION. PROCEEDINGS, 1960.

The papers in this volume, presented by linguists, mathematicians, and computer scientists demonstrate the diversity of the investigations and the advances in the automation and techniques of machine translation. They cover current research on various systems and projects. Studies in grammar, syntax, the dictionary, semantic and linguistie analysis, and programming are also presented, as well as a panel discussion on methodology. The papers on machine translation equipment discuss translation uses of high-speed general purpose computing machines, system design of a computer for machine translation, and character recognition machines. (H. P. Edmundson. Englewood Cliffs, Prentice-Hall, 1961. 525p., $7.95.)

*MANUFACTURING PROCESSES AND MATERIALS FOR ENGINEERS.

Beginning with an extended discussion of the metallurgy and heat treatment of metals, this work continues with a theoretical treatment of metal cutting, forming, and grinding. The use of statistical concepts and techniques is introduced in connection with inspection, measuring, and gaging. Automation is discussed from the theoretical as well as the practical standpoint, and the principles of fixed and selectable programming, self regulation, feedback, and numerical and analog control systems are explained. Emphasis is placed throughout on the technieal and economic principles which are basic to the manufacturing processes. (L. E. Doyle and others. Englewood Cliffs, Prentice-Hall, 1961. 797p., $15.00.)

*DESIGN AND CONSTRUCTION OF PORTS AND MARINE STRUCTURES.

The essential concepts of designing and building modern shipping-terminal, harbor, and offshore marine structures are presented. A wide range of material is included. It covers port growth and development, port design, breakwaters, piers, wharves, bulkheads, port buildings, material handling equipment, oil terminals, mobile docks, drilling and radar platforms, and navigation aids. Numerous worked out examples are given, and are illustrated with photographs and drawings. (A. DeF. Quinn. Toronto, McGraw-Hill, 1961. 531p., $18.50.)

*HANDBOOK OF AUTOMATION, COMPUTATION, AND CONTROL, VOL. 3: SYSTEMS AND COMPONENTS.

The third volume in this comprehensive handbook is largely concerned with systems engineering, manufacturing process control, chemical process control instrumentation, chemical process control systems, industrial control systems, and components. The treatment of components is largely concerned with how to select components among the various alternates, their mathematical description, and their integration into systems. There is also a treatment of the design of components of considerable importance today, specifically, magnetic amplifiers, semiconductors, and gyroscopes. (E. M. Grabbe and others. New York, Wiley, 1961. Various pagings, $19.75.)

COMBUSTION AND PROPULSION.

The Proceedings of the fourth AGARD Colloquium, dealing with air-breathing engines flying at high mach numbers. The thirteen papers were given by experts from Europe and the United States. The sessions covered: the future of air-breathing engines; the performance and applications of ramjets; hypersonic inlet studies; diffusion flames and detonation waves; nozzle flow with chemical reactions; research in turbomachinery; high temperature material problems. The discussions on the papers are also included. (A. L. Jaumotte. Oxford, Pergamon, 1961. 396p., $15.00.)

BASIC PHYSICS OF THE SOLAR SYSTEM.

Intended for engineers who are not specialists in astronomy, but who are interested in space technology, the aim of this volume is to present the basic physical and dynamical aspects of the solar system. The topics covered include: astronomical coordinate systems; the planets and their satellites, their orbits, shapes, rotation, atmospheres, etc.; the earth-moon system; celestial dynamics; the two-three- and n-body problems; the sun and interplanetary space. Numerous references for further reading are included. (V. M. Blanco and S. W. McCuskey. Reading, Addison-Wesley, 1961. 307p., $7.50.)

°SYSTEMS: RESEARCH AND DESIGN.

The fourteen papers included in this volume were presented at the First Systems Symposium held at the Case Institute of Technology in 1960. They discuss choice of objectives in systems studies; operations research in the study of very large systems; design of large-scale digital computer systems; impedance matching problems of systems that include men and computers; quantifiable parameters of group performance; reliability as a parameter in the systems concept; identification and evaluation of the transfer dynamics of physical systems; interrelationships of systems science and systems engineering in the processing industries. (Ed. by Donald P. Eckman. New York, Wiley, 1961. 310p., $8.50.)

COLOUR TELEVISION.

An account of the American National Television System Committee colour television system, and the British and European versions of the system, written primarily from the view point of the colour receiver engineer. The system is explained with particular reference to the 405 line version, but when there are differences between the 405, 525, and 625 line systems these are explained.

Subjects discussed in considerable detail are transmitter coding, receiver decoding, and the shortcomings of the N.T.S.C. systems. Other topics covered are: colour measurements; colour equipment, picture tubes, cameras and film scanners; colour receiver design and amplifiers; test equipment; receiver intallation; monochrome reception on colour receivers. Block diagrams, circuit diagrams and colour photographs are included, as well as a bibliography.

This volume appears at an opportune time, when both the transmission of regular colour programs is increasing, and extensive use is made of closed circuit systems for a variety of purposes. (P. S. Carnt and G. B. Townsend. Toronto, British Book, 1961. 487p., $23.50.)

°REACTOR HANDBOOK, VOLUME II: FUEL REPROCESSING.

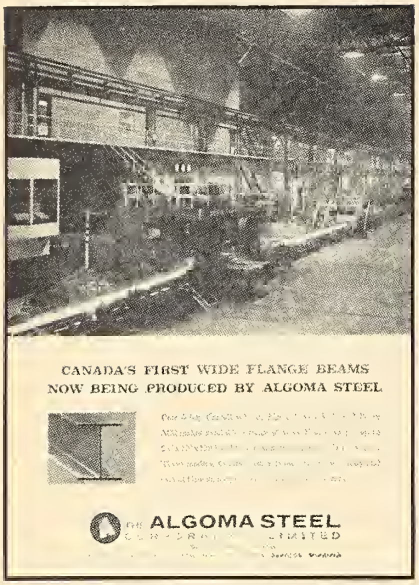
Those aspects of fuel reprocessing which are covered in this volume include aqueous separation processes, non-aqueous separation processes, reconversions, radioactive waste disposal, and engineering design, with emphasis on the engineering aspects. In this edition an attempt has been made to reduce the coverage of obsolete processes to a minimum and to extend the coverage of the first edition to include data on reconversion, isotope separation, plant, and equipment design and cost. Greater emphasis has also been placed on author references and correlating data rather than mere compilation. (S. M. Stoller and R. B. Richards. New York, Interscience, 1961. 665p., $21.40.)

INDUSTRIAL TRANSISTOR AND SEMICONDUCTOR HANDBOOK.

A basic text on semiconductors, covering their physics, general characteristics, ratings and measurements. The use of semiconductors in a variety of applications is discussed, including in industrial control, as power converters, in communications, and in solar-energy conversion. There is a chapter on manufacturing techniques, and another predicting future developments for semiconductors. (R. B. Tomer. Indianapolis, Sams, 1961. 254p., $4.95.)

(Continued on page 117)

EIC CERTIFICATE OF ADVERTISING MERIT



Although the majority of award winners occupy two or more pages of space, The Algoma Steel Corporation, Limited, Sault Ste. Marie, Ontario, has shown that a striking one-page advertisement can capture the Journal's Monthly Award. Judged best in the December issue was their full colour bleed advertisement on page 69, headed "Canada's First Wide Flange Beams Now Being Produced By Algoma Steel".

The undoubted key to the advertisement's success was a remarkably colourful photograph of the mill floor in action with (presumably) the white hot flange beams being produced. Copy gave full credit to the Canadian mill builders and workmen involved, and quoted beam sizes available.

The advertising of Algoma Steel is under the direction of Mr. L. Brown, Administrative Assistant to the President. The winning advertisement was produced by the Toronto office of Cockfield, Brown & Company Limited, Mr. F. D. Adams, Account Executive.

Each month a different panel of fifty Journal readers from across Canada is asked to nominate an award-winning ad of their choice from the viewpoints of ACCURACY — INFORMATION — ATTRACTION.

(Continued from page 113)

TWO OF CANADA'S newest pipeline bridges feature three and one half miles of wire cable constructed by British Ropes Canadian Factory Limited, at Vancouver. One bridge carries a gas line over the Bow River near Cochrane, Alta., and the other supports an oil line over the Fraser River at Shelly, B.C.

TYPE AKA, a feed-through terminal for panel and chassis connections is a new item introduced into the extensive range of Staffel Terminal Blocks. It incorporates the basic design features and high-grade materials of the whole Staffel family. Type AKA, a product of Electrovert Limited of Montreal, has been developed for use in electrical and electronic equipment.

THE MECHANICAL DIVISION of Dominion Bridge Company Limited has been awarded a contract for $400,000 by English Steel Rolling Mills Corporation to supply four special type cranes for use at Tinsley Park, a new $75 million steel-making complex now under construction at Sheffield, England. Dominion Bridge has also acquired sole Canadian manufacturing rights to produce powered platforms for the cleaning and maintenance of exterior walls of buildings developed by the Manning and Lewis Engineering Company of Newark, N.J. This equipment called a wallglider, consists of a roof car and a mechanized aluminum platform providing coverage of the entire external wall surface of skyscrapers.

THE PRESTRESSED CONCRETE Institute has announced the publication of its new Prestressed Concrete Building Code Requirements. This is the first national Code published on the subject and is intended as an aid to engineers, architects and building officials. It is written so that it may be incorporated as a part of any general building code. The code includes all design requirements such as: allowable stresses in concrete and steel, load factors, ultimate flexural strength, and shear.

THE UNITED STATES Department of the Interior, Office of Saline Water, has selected Burns and Roe Inc., to manage, operate and maintain its sea water conversion demonstration plant at San Diego, California. This multi-stage flash distillation facility has a capacity of one million gallons of potable water per day. This project is part of a program to determine the engineering feasibility and economics of converting sea water to high-quality fresh water for municipal, industrial, and other uses.

A SPECIAL DUTY tire valve core for off-the-road and other heavy-duty equipment has been introduced by Dill Manufacturing Company. The valve core, Model VI-70-HH, is designed to operate perfectly in temperatures ranging from −65° to 450°F., and for short periods, it can withstand even greater temperatures. Construction is the same as that used for jet planes. The fully enclosed stainless steel spring is sturdy, compact and oil resistant. The valve core has a .302 inch-32 thread to fit oversize valves and features a silicon heat resisting cup gasket.

THE LEVITT-SAFETY LIMITED has introduced a new Multi-Fog Nozzle operable at water pressure of 25 psi and up. It has fog patterns from shut-off directly to 30 degrees fog and adjustable through to 90 degrees fog are available. The no-straight-steam feature eliminates the hazard of spreading flammable liquid fires, accidental electrocution and reduces the costly water damages which might occur if a straight-stream were available. The nozzle has been approved by the Underwriters' Laboratories for Class "A" (Ordinary Combustibles), Class "B" (Flammable Liquids) and Class "C" (Electrical) fires.

A MORE POWERFUL drill for use in the pit, quarry, and construction industry has been introduced by Canadian Ingersoll-Rand. The D-475 Drifter, which is mounted on the Crawl-IR, Crawler Drill, employs a drill rotation method and drills holes in the 2½ inch to 4 inch range, increasing penetration up to 35%. The D-475 rotates only on the upstroke of the piston and in so doing, avoids rapid bit wear from rotation during impact. This new rotation method enables the drill to stay in operation longer and is not subject to the operator's whims.

A COMPLETE LISTING of precision levels, including plain, reversion, spring mounted, circular and unmounted vials, are featured in a newly revised and expanded bulletin published by W. & L. Gurley of Troy, N.Y. Gurley spirit levels, aside from the usual ones in surveying instruments, have many applications on heavy machinery, missile platforms, air frames, launching pads, rolling mills and other mechanical devices where absolute level is essential.

THE CAMBRIDGE INSTRUMENT Company of London, England, has introduced the Scanning Reflection Electron Microscope. This experimental microscope is being developed primarily for the examination of specimens that have comparatively rough surfaces or characteristics that preclude the use of extraction replica techniques. It is intended to be largely complementary to the transmission electron microscope. Other applications are likely to include the examination of delicate fibres and the study of voltage gradients across semi-conductor junctions and similar phenomena.

THE COPPER RANGE Company has published the first in a series of illustrated technical volumes entitled Copper Range — White Pine — Lake Copper — Properties. Later books will cover research on fabrication and alloys. This first volume outlines briefly the history of copper production of the Lake Superior region and the Company's participation, including the development of the White Pine Copper Company, its subsidiary.

(Continued on page 118)

(Continued from page 115)

*PROBABILITY AND EXPERIMENTAL ERRORS IN SCIENCE.

The author begins with a brief discussion of the different meanings of probability, introducing games of chance as examples of the classical or a priori meaning. He then considers measurements in science and such general statistical concepts as maximum likelihood propagation of errors, curve fitting, least-squares method, consistency tests, analysis of variances, and correlation. The normal (Gauss) and Poisson models of mathematical probability are explored both analytically and through typical problems. (L. G. Parratt. New York, Wiley, 1961. 255p., $7.25.)

*COST REDUCTION GUIDE FOR MANUFACTURING MANAGEMENT.

Following a description of the characteristics and techniques of a successful cost reduction program, the authors present a variety of specific case histories illustrating the application of these techniques. They conclude with a listing of operations analysis questions which when applied will develop an accurate profile of company strengths and weaknesses. The experiences of more than fifty companies in planning, organizing, and promoting cost reduction programs are reflected in this volume. (H. Morse and E. E. Wyatt. Chicago, Wyatt & Morse, 1961. 244p., $18.00.)

AN INTRODUCTION TO THE PROPERTIES OF ENGINEERING MATERIALS.

Based on an undergraduate course covering the fundamentals of the structures of materials, the text commences with the physics of the atom and the various types of inter-atomic bonding, followed by the assembly of atoms or molecules in gases, liquids and solids. Crystalline structure is also covered in enough detail to enable the student to understand the mechanical behaviour of metal crystals. The remaining chapters are of a more technical nature, and cover the mechanical testing of metals, and the relationship of the results of tests for toughness, fatigue and creep to engineering design, the heat treatment of steel, alloy steels, corrosion problems and the metallurgical factors in welding. The last chapter introduces some of the problems to be considered when using materials in nuclear engineering projects. (K. J. Pascoe. London, Blackie, 1961. 295p., 35/-.)

*ENGINEERING CASTINGS.

A simplified presentation of technical information on the various types of castings and how they are made, the selection of metals, and various design factors. It offers sound procedures for selecting a foundry, obtaining quotations and ordering castings, and setting up a contract. Also provided is concise information on how to buy patterns. (G. J. Cook. Toronto, McGraw-Hill, 1961. 257p., $9.75.)

LONG RANGE BALLISTIC MISSILES.

Already well-known for his books on rockets and space technology, the author travelled all through the U.S. gathering material for this volume, visiting plants, missile ranges and test centres. He discusses the history of the ballistic missile, and the U.S. programme, and how the missile fits into the overall picture. He considers missile trajectory, missile components, re-entry bodies (nose cones), facilities required for launching, etc., and finally, the peaceful uses of missiles. Many photographs are included. (Eric Burgess. Toronto, Ryerson, 1961. 255 p., $7.00.)

*AXIAL-UND RADIALKOMPRESSOREN.

New enlarged edition of a treatise on the application, theory and calculations of axial and radial-flow compressors, presenting an extensive review of the fundamentals of modern turbo-compressors (except supersonic) as well as detailed treatment of special types. There are also brief chapters on turbomachines under unstable operating conditions and on regulation of compressors. There is an extensive bibliography. (B. Eckert and E. Schnell. Berlin, Springer-Verlag, 1961. 527p., DM 89.00.)

(Continued on page 125)

(Continued from page 116)

THE PETER BENT Brigham Hospital of Boston has ordered from the High Voltage Engineering Corporation of Burlington, Mass., a powerful six million-electron-volt micro-wave linear accelerator for cancer therapy and research. This machine is capable of producing sharply defined, deep penetrating X-rays at distances which protect against skin damage and death dosages which reduce treatment time.

A NEW GRAVITY reference surface that makes it possible to relate an optical tooling co-ordinate system to the gravity vector now is available from Keuffel and Esser Company. The device is a spherical Bernoulli bearing which behaves as a stable liquid reflectant surface without displaying the inherent instabilities present in liquids. It can be used to check alignment of missile launching pads, radar and radio antennas and wherever seismic vibrations and angular movement have to be monitored.

A MULTI-MILLION dollar contract to make the heavy mill equipment for the Steel Company of Canada's new 80-inch cold mill in Hamilton has been awarded Canada Iron Foundries Limited. A Stelco official said the new mill is a major item in the $40 million expansion program, and will enable Stelco to roll hot and cold sheet metal in widths not now made in Canada.

MILLER SWIVEL Products Incorporated, Pomona, Calif., has announced the additional facility of a 350 Ton Tension or Compression Testing Machine. This machine allows accurate testing to within 1% accuracy.

A FULLY AUTOMATIC Mimik Coordinate Feed Control for use in combination with the standard Mimik 4000 Rise and Fall Duplicator has been developed by Retor Developments Limited, Galt, Ont. The duplicator control, which attaches to any quill type mill without machine conversion, provides a fully automatic die sinking operation at remarkably low cost.

THE FEDERAL EQUIPMENT (Eastern) Limited, Montreal, has signed a distribution conrtact with Harnischfeger Corporation of Canada Limited. Harnischfeger's P & H line of heavy equipment, including all models manufactured under contract in Canada by John Inglis Company, Toronto, will be distributed throughout Quebec by the Montreal firm.

MODEL NO. 928, is the new precision grinder introduced by the Kaydon Engineering Corporation. It is designed to contour grind flow-turn mandrels and other missile components up to 108 inches in height. The new grinder has been designed for the rocket engine program of the Saturn missile at Cape Canaveral.

A TRANSISTORIZED radio direction finder which operates from six standard flashlight batteries has been introduced by Raytheon Canada Limited. The Model 356 Ranger II has been designed to receive the long-range Consolan direction finding signals. It has a built-in beat frequency oscillator and covers the Consolan band to receive lines of position from Nantucket, San Francisco, Miami, and five Consol stations in Europe.

FIRE HOSE with a single jacket of 100% Canadian terylene polyester fibre is now being supplied to municipal fire brigades and industrial plants in Canada by La France Fire Engine and Foamite Limited, Toronto. Under the name Crusader, the hose jacket is made from 1100 denier, high tenacity bright yarn with a Neoprene liner and is being produced by the Goodyear Tire and Rubber Company of Canada Limited following a period of intensive development and testing over the past year.

THE DEVELOPMENT of a complete family of compression-ignition multifuel engines that can be operated on a complete range of fuels from diesel to gasoline has been announced by General Motors Diesel Limited, London, Ont. These engines were developed primarily for military use, but commercial applications are also foreseen. Twelve V and in-line models offer a wide power selection.

The Engineering Institute of Canada

75TH ANNIVERSARY

ANNUAL GENERAL MEETING

Montreal, Quebec

Queen Elizabeth Hotel

JUNE 12 - 15

ASME-AIEE-EIC
JOINT RAILWAY CONFERENCE
Toronto
April 9-10
King Edward Hotel

THEME: Metropolitan Transportation

Monday, April 9

SESSION I — **9:30 a.m.**

Problems of Selecting a Type of Urban Transportation
W. E. P. Duncan, Toronto Transit Commission, Toronto (ASME)

Rapid Transit Planning—The Background of Metropolitan Growth
S. D. Forsythe, National Capital Transportation Agency, Washington, D.C., (ASME)

Railroad Noise Problems
T. D. Northwood, National Research Council, Ottawa, (EIC)

• • • •

SESSION II — **2:00 p.m.**

The Evolution of a Modern Transit Vehicle Structure
J. W. Borger, Pullman-Standard Company, Chicago (ASME)

Aluminum Subway Cars for Toronto
I. G. Hendry, Toronto Transit Commission, Toronto, and D. H. Hellman, Vapor Heating Limited, Montreal, (EIC)

The Toronto Subway Tunnel Shields
T. M. Noskiewicz and J. V. Bartlett, W. S. Atkins & Associates, Toronto, (EIC)

• • • •

Tuesday, April 10

SESSION III — **9:30 a.m.**

Some Problems Encountered in Design of Automatic Freight Train Controls
R. G. McAndrew, General Railway Signal Company, New York City (AIEE)

Simulation of Train Operations on a Digital Computer
P. B. Wilson, C. J. Hudson, and C. Sankey, Canadian National Railways Montreal, (ASME)

Modern Light Sources for the Railway Industry
R. D. Churchill and L. L. Henderson, General Electric Company, Cleveland, (AIEE)

• • • •

SESSION IV — **2:00 p.m.**

Static Conductor for Railroad Use With Particular Emphasis on Rapid Transit Cars
W. C. Allison, Canadian General Electric Company, Peterborough, Ont. (AIEE)

Traction Motor Suspension Design
Carl F. Simon, Jr., General Electric Company, Erie, Pa. (ASME)

The Fundamentals of Infrared Hot Box Detection
E. G. Menaker, General Electric Co., Waynesboro, Va., (AIEE)

Silicon Rectifier Cells for Power Rectification on Railway Vehicles
H. S. Ogden and E. F. Weiser, General Electric Co., Erie, Pa., (AIEE)

• • • •

FEES: A Conference fee of $5 for ASME, AIEE, and EIC members, and an $8 fee for non-members will be charged. A fee of $1 will be charged to students and there will be no registration fee for the ladies.

LADIES: There will be a program for the ladies who intend to join their men at the Conference. Various activities have been planned which include a morning coffee hour on Monday and a luncheon and tour of the city on Tuesday.

Library Notes

(Continued from page 117)

DECISION MODELS FOR INVENTORY MANAGEMENT.

Methods for the management of multi-item inventories re presented. The inventory situation, in several basic orms, is described graphically and mathematically, and nodels are developed which can be used to determine ptimal inventory policy in a variety of cases. The data equirements for the inventory models are discussed at ength. The nature of the costs required by the models nd their relative sensitivity under various inventory conlitions are reviewed. (R. B. Fetter and W. C. Dalleck. Iomewood, Ill., Irwin, 1961. 123p., $5.75.)

SING THE OSCILLOSCOPE IN INDUSTRIAL ELECTRONICS.

The use of the oscilloscope for testing and maintaining ndustrial electronic devices. The first four chapters contain eneral information on industrial oscilloscopes, information apability, operating features, and characteristics. Six hapters discuss specific applications in testing and mainaining thyratron and ignitron controls, saturable reactors nd magnetic amplifiers, radar equipment, automotive igniion systems and transistorized controls. The final chapters over waveform photography, the use of oscilloscope in the iboratory, and maintenance. (R. G. Middleton and L. D. Payne. Indianapolis, Sams, 1961. 256p., $4.95.)

ANDBOOK OF ELECTRONIC CHARTS AND NOMOGRAPHS.

A set of 58 nomographs and charts for deriving answers o electronic formulae. There are brief instructions for the se of each nomogram, and an example is given of the olution of a typical problem. A vinyl overlay sheet is ncluded, so that pencil lines may be ruled on the nomoram, for greater accuracy. (A. Lytel. Indianapolis, Sams, 961. 127p., $4.95.)

TECHNICAL BULLETINS & PAMPHLETS RECEIVED

Space limitations do not enable us to record these in the Library Notes. A mimeographed list of the Bulletins and Pamphlets received during the last month is available free on request to the librarian.

*COMBUSTION, FLAMES AND EXPLOSIONS OF GASES, 2ND. ED.

The purpose of this text is to provide the chemist, physicist, and engineer with a scientific basis for understanding combustion phenomena. It is divided into four parts dealing with the chemistry and kinetics of the reactions between gaseous fuels and oxidants, flame propagation, state of the burned gas, and problems in technical combustion processes. In this new edition particular emphasis has been placed on the modification of combustion wave propagation due to heat loss to the unburned medium and to localized changes of mixture composition by diffusional processes. Some revisions have been made in the discussion of detonation processes, and new material has been included where appropriate. (B. Lewis and G. von Elbe. New York, Academic, 1961. 731p., $22.00.) EIC

INDEX TO ADVF TISERS

MARCH 196

PUBLICATION OFFICES: The Engineering Institute of Canada, 2050 M. . ld Street, Montreal 2, Quebec, Canada.

Association of Consulting Engineers of Canada Incorporated

The following firms have principals who are members of this Association engaged as professional engineers in engineering work independent of salaried employment or sales promotion.

The revenue derived from the sale of advertising space assists the Institute in publishing THE ENGINEERING JOURNAL on a regular monthly basis. Listed above are the names of the Companies and individuals whose advertisements appear in this issue.

ADVERTISING OFFICES

QUEBEC: J. E. Donovan, Manager, Advertising Sales—D. W. Campbell, 2050 Mansfield Street, Montreal, Phone: VIctor 2-8121
ONTARIO: L. G. Barnum, Manager, Advertising Sales, 160 Eglinton Ave. E., Suite 103, Toronto, Phone: 485-0789
WESTERN CANADA: W. George Turner, 501 - 191 Lombard Ave., Winnipeg, Man., WH 3-9123
EUROPE: H. A. Mackenzie, 4A Bloomsbury Square, London, W.C.1, England. Phone: HOlborn 3779
NEW ENGLAND STATES: R. G. Melendy, 17 Maugus Avenue, Wellesley Hills 81, Mass. Phone: CEdar 5-6503
CHICAGO: W. Reynold Ratz, 549 W. Randolph St., Chicago 4, Ill. Phone: ST-2-8811
NEW YORK: John H. Boyd, 17 East 45th Street, New York, Phone: MUrray Hill 7-0654

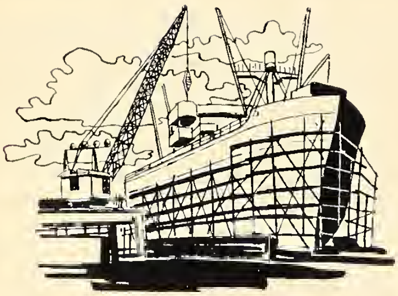
EIC

THE
ENGINEERING JOURNAL

VOLUME 45 NUMBER 4 APRIL 1962

BLISHED MONTHLY BY THE ENGINEERING INSTITUTE OF CANADA, 2050 MANSFIELD ST., MONTREAL 2, QUE., CANADA • TEL. VI. 2-8121

CONTENTS



THE CHALLENGE OF PROGRESS

Canada's progress of recent years offers an irresistible challenge. Her stepped-up industrial program, her ever-expanding mining and oil interests, the St. Lawrence Seaway & Power Project, are just some of the signs of Canada's growth. Marine Industries Limited is proud to be a part of that growth and to meet the challenge of progress in dredging Canada's waterways and in building, repairing and converting the ships that sail them.

Marine Industries Limited

MONTREAL • SOREL

IN THIS ISSUE

"*Geology of the South Saskatchewan River Project*", by **D. H. Pollock**, M.E.I.C., Chief, Air Photo Analysis and Engineering Geology Division, Prairie Farm Rehabilitation Administration, Regina, presents readers with an appreciation of geological features and events that have exerted a significant influence on various phases of engineering of the South Saskatchewan River Project, such as the preliminary damsite-selection program, the flood plain and abutment investigation, the exploration for construction materials and the design of the dams and their appurtenant works. The paper makes only limited reference to the significance and application of the geology as this subject matter would be better discussed under heading dealing in detail with project investigation design and construction.

No attempt has been made to deal fully with every aspect of the design and construction problem. Detail description has been confined to those items where existing literature is scanty and where the author feels that information of interest can be presented.

Recent observations of the radio emissions from celestial objects have provided astronomers with much new information. These observations have also shown the need for radio telescopes having larger apertures than those now available. For centimetre wavelengths, the only suitable type of telescope appears to be one having a large reflecting surface. **J. L. Locke**, Officer in Charge, Dominion Radio-Astrophysical Observatory, Department of Technical Surveys, Penticton, B.C., in his paper "***Design Considerations for Large Radio Telescopes***", discusses the factors influencing the design of radio telescopes of various sizes for use at different wavelengths and outlines the manner in which the problems have been solved in existing and planned telescopes. He also discusses the possibility of telescopes of extremely large apertures.

It is more than 40 years since the first feed-heating system for land power stations was installed in Britain, although this installation had been preceded for some time by the use of feed heaters in marine work. The present state of the practice of feed heaters is however, much removed from the relatively simple equipment of those days. **J. V. Bigg**, in his paper "***Power Station Feed Heaters***", presents a brief survey, firstly of some of the performance considerations involved, and secondly of several of the detail features and construction problems involved in present-day plant.

Potash is one of the major components of modern-day fertilizers. Until recently, potash had to be imported from New Mexico and transportation constituted a great part of the cost. When potash was discovered in Esterhazy, Sask., plans were started for the development of the rich and important mine. Since the demand for fertilizer is highly seasonal, it is necessary to have storage facilities to accommodate several months production. In his paper entitled, "***Unique Design in Glulam***", **B. Madsen**, Chief Engineer, Glulam Products Limited, New Westminster, B.C., describes the construction of these storage buildings. The problem faced was to develop a design which would meet the special requirements. The pile to be covered consisted of a 204 ft. diameter cylinder 16 ft. in height, located below the ground level. The potash would form a 62 ft. high cone on top of this. The structural frame would have to be entirely outside of this space. The paper describes the selection of the materials, the design, testing and other pertinent factors of this project.

T. W. McDonald and **P. N. Nikiforuk**, Assistant Professors of Mechanical Engineering, University of Saskatchewan, in their paper, "***Some Engineering Applications of Analog Computers***" subdivide analog computers into two main groups: the special purpose machines; and the general purpose machines. As an introduction to the subject, a general description is first given of these two groups. Following this a detailed description is given with examples, of conducting sheet analogs, resistance-capacitance network analogs and d.c. electronic analog computers. These computers are compared consequently as far as accuracy, flexibility and maintenance are concerned. Some of the examples quoted are descriptions of work being done at the Mechanical Engineering Department at the University of Saskatchewan.

COVER ILLUSTRATION

Shown is a view of one of the downstream tunnels of the South Saskatchewan River Project presently under construction. The site of the tunnel is midway between the towns of Outlook and Elbow. (Photo courtesy Prairie Farm Rehabilitation Administration, Canada Dept. of Agriculture)

Geology of the South Saskatchewan River Project

D. H. Pollock, M.E.I.C.,
Prairie Farm Rehabilitation Administration, Regina
Chief, Air Photo Analysis and Engineering Geology Division

Presented at the 75th E.I.C. Annual General Meeting, Vancouver, May 1961.

PURPOSE OF this paper is to present readers with an appreciation of geologic features and events that have exerted a significant influence on various phases of engineering of the South Saskatchewan River Project, such as the preliminary damsite-selection program, the floodplain and abutment investigation, the exploration for construction materials, and the design of the dams and their appurtenant works. The paper makes only limited reference to the significance and application of the geology as this subject matter would be better discussed under headings dealing in detail with project investigation, design and construction.

The project is a joint undertaking by Canada and Saskatchewan to utilize waters of the South Saskatchewan River for irrigation, generation of power and river regulation. Construction of two earth-fill dams is a major feature of the project. The main dam will be the 210 ft. high South Saskatchewan River Dam, located midway between the towns of Outlook and Elbow. The 90 ft. high Qu'Appelle River Dam will be the second dam, and will be required on the Qu'Appelle River roughly 12 miles southeast of Elbow to prevent reservoir water from escaping easterly down the valley. Sites of both dams are shown in Fig. 1. The project also entails construction of hydro-electric power facilities at the main dam and construction of an irrigation distribution system of outlet works, canals and anxilliary reservoirs for the ultimate irrigation of approximately 500,000 acres of land. Canada is responsible for design and construction of the fills and spillway and river diversion structures, whereas Saskatchewan is responsible for the design and construction of the hydro-electric installations and the irrigation distribution system. The main dam will have a volume of more than 64 million cu. yd. and will be one of the largest in the world.

A previous paper by MacKenzie[1]

This paper is based on studies completed to the end of 1960. More recently, additional detailed data from deep excavations in the shale have become available.

presents a comprehensive outline of the project's major engineering and agricultural features as well as the history of the project from Palliser's earliest thoughts in 1857 through to the present. A second paper by Berry, Durrant, and Booy[2] present hydrological aspects of the project. Papers by Peterson[3, 4] discuss engineering properties and detailed investigations of the Bearpaw shale, which is the bedrock formation underlying the damsites. A paper by Booy,[5], presented at the 1961 E.I.C. Annual Meeting, discusses the structural design of the diversion tunnels for the main dam.

Construction at the main damsite is well underway. Major contracts let to date include construction of the tunnels, processing of concrete aggregates, and placement of various stages and zones of the fill.

Early Investigations

Early investigations by P.F.R.A. were directed toward finding a site in the Cabri reach of the river to divert water through the Whitebear Depression for irrigation in the vast Elrose-Rosetown - Outlook - Saskatoon area. Fig. 1 shows six different sites on which the consulting geologist submitted recommendations. Three of the more favorable sites, 3, 4 and 5, were drilled.[6] Fig. 2 shows the locations and geologic profiles along the centrelines. Although the program was limited and presented only a gross picture of the geology, it was sufficient to reveal rather surprising and somewhat discouraging conditions in the valley bottom. Prior to the last glaciation, an ancestral river cut a deep valley at these locations into the bedrock Bearpaw and Belly River formations. The river then aggraded depositing between 150 to 200 ft. of sand on the valley bottom. A later ice sheet, most likely the last in this area, mantled the valley and adjacent uplands with till. However this till was not thick enough to mask the valley completely, and a shallow, trough-like depression survived the glaciation to become a natural course for postglacial drainage, now known as the South Saskatchewan Rive This river cut into the till and i some cases into the underlying san to an elevation of roughly 1700 ft and then entered a period of aggrad ation continuing to the present. Th geologic profiles of Fig. 2 indicat the river is not accurately superpose on the course of its predecessor ove the full reach between Sites 4 and 5

Concurrent investigations indicate a dam at any one of the three Cabr sites would have several shortcom ings. Costs of the spillway and rive diversion structures relative to th volume of storage would be very high Considerable valuable agricultura land in the valley and in low-lying land adjacent to the valley would be inundated. In addition, agricultural soil surveys indicated that much o the land in the Elrose-Rosetown district originally considered for irrigation had too high a clay content and was not suitable for irrigation. Investigations were then suspended in the Cabri reach of the river and directed toward the Elbow-Outlook reach, where a dam could divert

Fig. 1. Drainage Map Showing Sites under Construction and Other Sites Investigated.

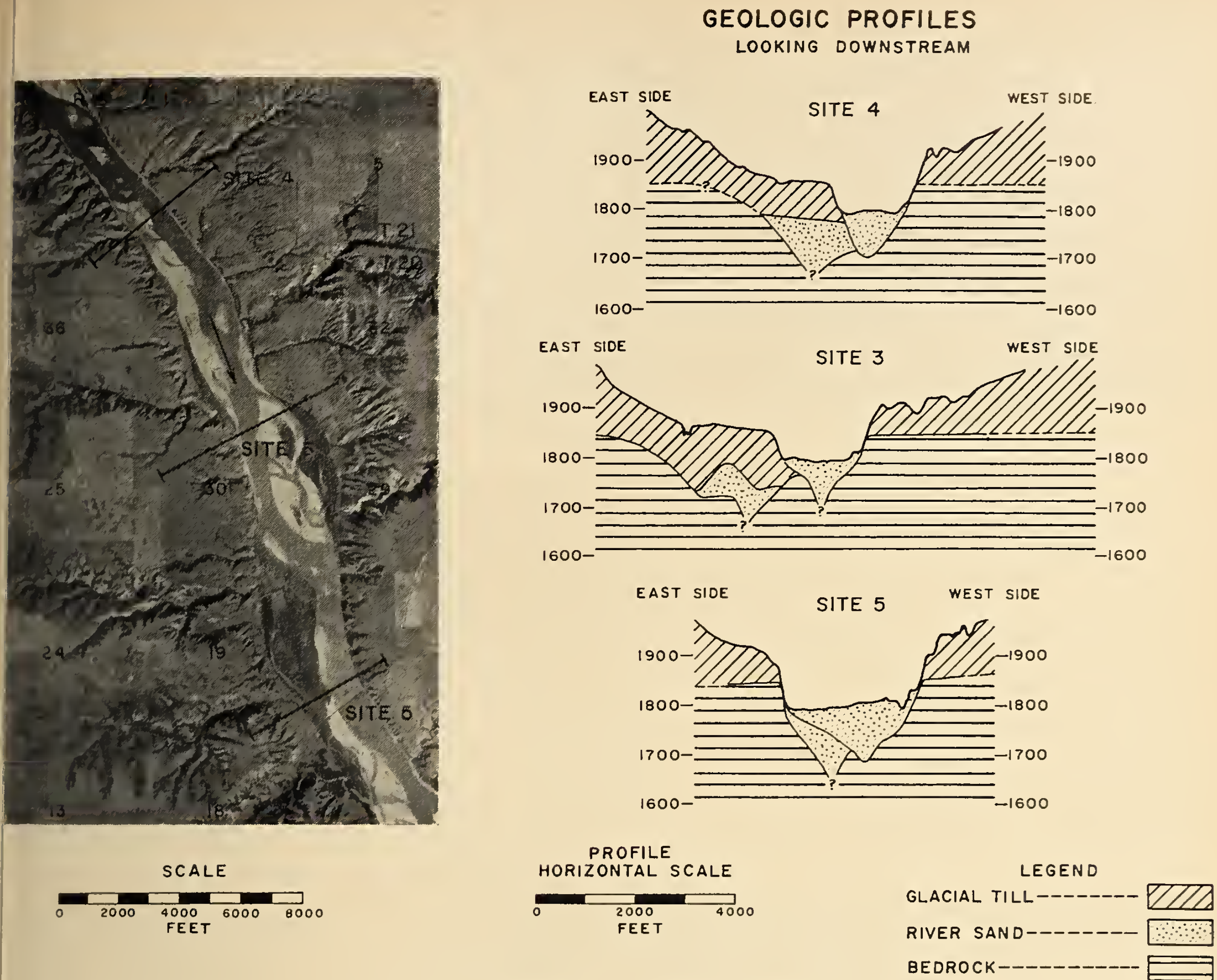


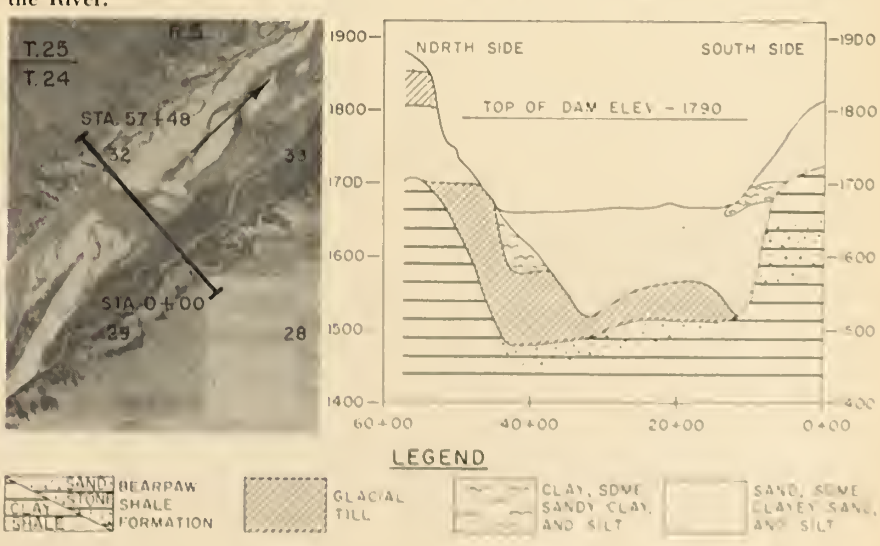
Fig. 2. Sites 3, 4 and 5 along the Cabri Reach of the River.

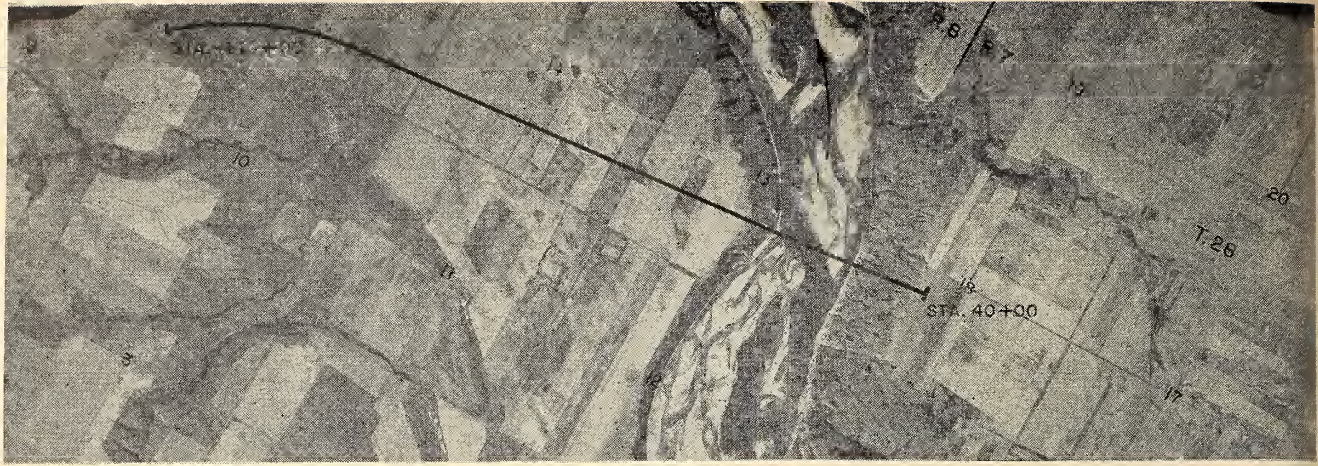
vater down the Qu'Appelle Valley as vell as service irrigable areas in the listrict east of Outlook and in the reviously mentioned Outlook-Saskaoon district west of the river.

Fig. 1 shows the four sites, 7, 8, and 10, selected for study along he Elbow-Outlook reach. Investigaions at Sites 7 and 9 were abandoned oon after comparative studies with ites 8 and 10 indicated severe probems with respect to construction maerials, spillway location, and foundaion conditions. In addition, volume of torage was considerably less than hat of Site 8 or 10. A limited testole investigation at Site 9 indicated he present-day river cut its valley nto a deeper till-infilled valley that reviously was eroded into the Bearaw shale formation by some anestral South Saskatchewan River. 'ig. 3 indicates the prominent geoogic features of Site 9. It is apparnt the valley at this site has undergone a geologic development somevhat similar to that near Sites 3, 4 nd 5 in the Cabri reach.

Both Site 8 and Site 10 were investigated to considerable detail before a decision was made in favor of Site 10, now known as the South Saskatchewan River Damsite. The geology of this site will be discussed in detail under a later heading. Site 8 entailed a particularly difficult spillway location and a volume of fill much greater than that of Site 10. Fig. 4 shows the subsurface geology as revealed by testholes drilled along the centreline of the site. Significant characteristics of the bedrock include the predominance of sandy shale and sandstone. These sandy facies may represent the Belly River sandstone

Fig. 3. Geologic Profile of Centerline of Site 9 along the Elbow-Outlook Reach of the River.





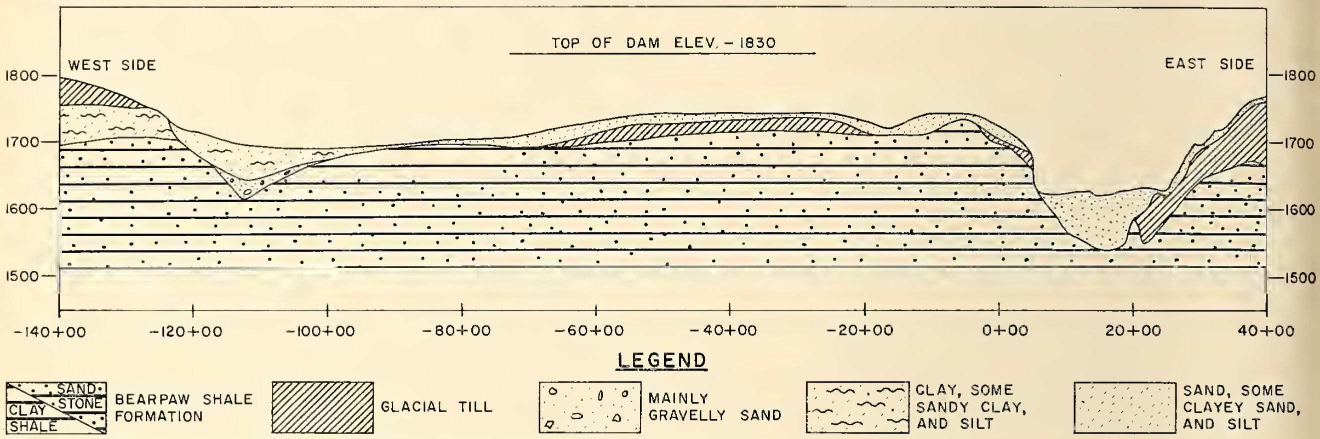
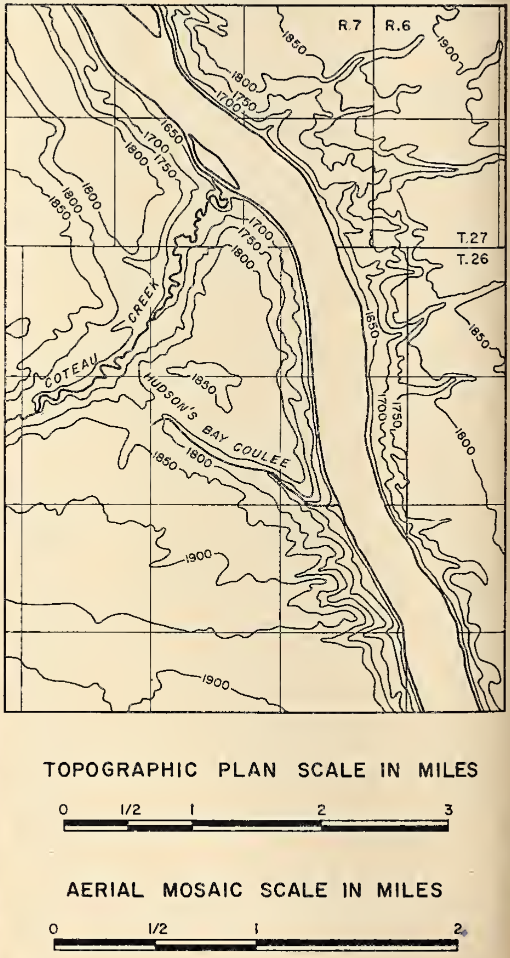


Fig. 4. Geologic Profile of Centerline of Site 8 along the Elbow-Outlook Reach of the River.

Fig. 5. Mosaic and Topographic Plan of South Saskatchewan River Damsite.



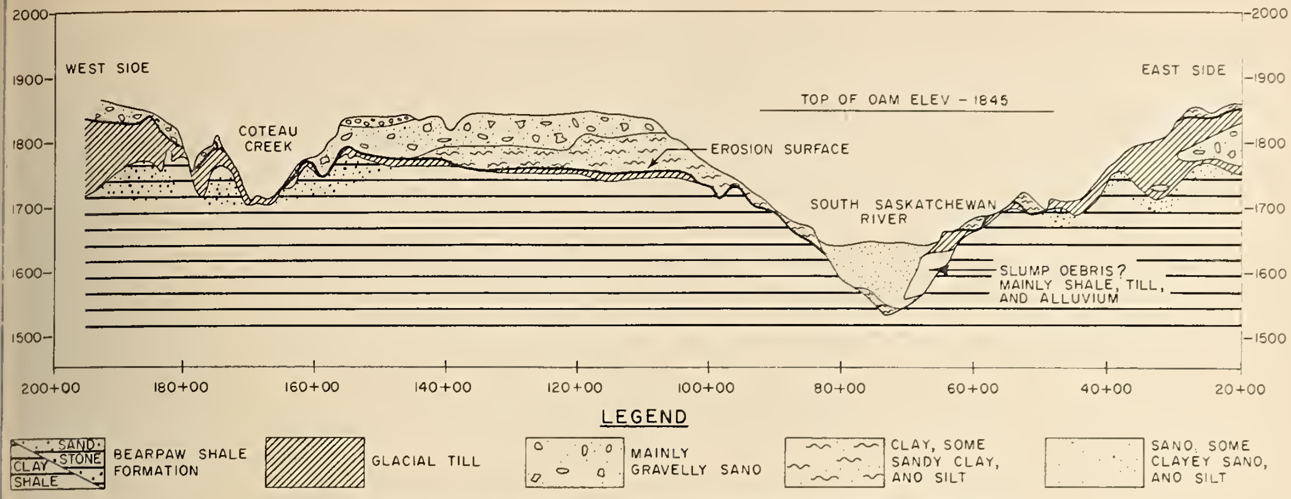


Fig. 6. Geologic Profile of Centerline—South Saskatchewan River Damsite.

ormation and transitions to the overlying Bearpaw shale formation. Bedrock in the far west abutment appears to be directly overlain by a relatively thick stratum of lacustrine silt and clay. Both abutments incorporate till, which, near station 40+40 of the east side, has a noteworthy thickness of up to 100 ft. Both are mantled by a thin deposit of lacustrine sand and silt. The broad and flat low-lying bench west of the present-day valley has a mantle of fine sand and silt overlying a thin stratum of till, which in turn overlies bedrock. A former course of the river is indicated at the western limit of this area. Since abandonment by the river, this immediate area has been covered by up to 50 ft. of highly plastic clay, thought to be mainly slope wash from the nearby west abutment. The east abutment appears to have undergone considerable movement when the river was near its lowest level of erosion. Here, shale and till debris appears to be overlain by up to 90 ft. of sand deposited by the river.

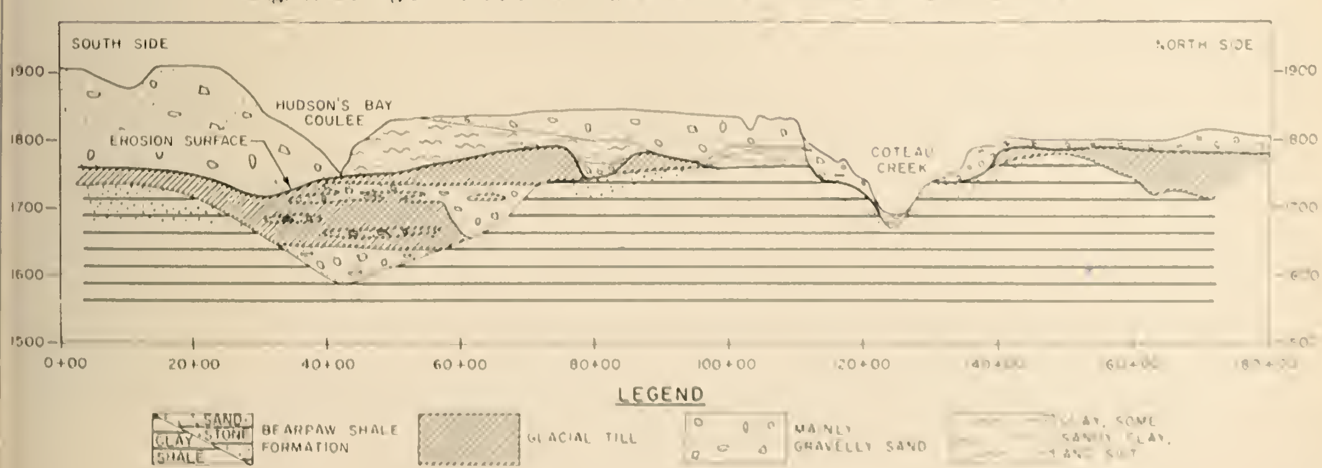
As construction of dam at Site 8 or Site 10 would necessitate a dam on the Qu'Appelle Valley, a site-selection program was carried out along the valley. Such a dam would not only prevent escape of water to the east, but would also serve as a crossing for the Canadian Pacific Railroad leading north to Elbow. A major consideration in the location of the dam was that an easterly location would result in increased storage but at expense of an increased length of relocated railroad. Both foundation and topographic conditions vary widely along the valley, and it was necessary to investigate a total of five sites to arrive at a satisfactory solution. These sites are indicated on Fig. 1 and Fig. 11. The testhole drilling indicated the geology of the valley bottom varies markedly over a reach of 34 miles. The Summit Site was selected as the most satisfactory site for the dam, which is to be known as the Qu'Appelle River Dam. Geology of this site along with a limited discussion on geologic development of the valley will be discussed under a later heading.

Geology of the South Saskatchewan River Damsite

A mosaic and topographic plan of the vicinity of the main site are given in Fig. 5. Fig. 6 is a geologic profile of the centreline; Fig. 7 is a profile showing the prominent features of the geology on the west side of the site.

Bearpaw Shale Formation: The Bearpaw shale formation of Upper Cretaceous age underlies the drift at this site. The formation is of marine origin and commonly dark grey in color. Bulk of the formation is a clay shale. Lenses and zones of silty and sandy shale and sandstone are present to a lesser amount. Layers of bentonitic shale have been identified but are uncommon. Textural classification tests indicate the average shale sample is composed of roughly 50% clay sizes, 33% silt sizes and 17% sand sizes. Tests on sandstone samples indicate up to 40% of the material lies in the sand size. It is pertinent to note that many samples

Fig. 7. Geologic Profile Across Deltaic Sediments on West Side of Main Damsite.



commonly described as sandstone by geologists have Atterberg limits that would classify them as medium to highly plastic in the Unified Soil Classification. Tests to identify the type of clay in the shale have been made by several investigators. Christiansen[8] tested samples from the Swift Current area, some 60 miles southwest of the site, and found montmorillonite to form between 80% and 85% of the samples, illite to form between 15% and 20%, and traces of kaolinite to be present. The shale has no cementing agent. Accordingly, upon exposure to weathering elements, it absorbs water, swells and soon slakes into a highly plastic clay.

The structure of the shale appears to range between massive and faintly bedded. The few bentonite layers that are present range up to 1 ft. in thickness and are well defined and appear to persist laterally over limited distances. Both vertical and lateral textural changes in the sandstone and sandy and silty facies of the shale are seldom abrupt and are often poorly defined. The sandy facies seem most prevalent in elevations above 1720. However a deep testhole, RD639, in the SE ¼ 2-27-2-3 encountered clay shale between elevations 1750 and 1450 and sandstone and sandy shale from elevation 1450 to the bottom of the hole at elevation 1335. Slickensides and localized joints with warped surfaces are characteristic of the shale in the upper zones but appear to diminish in frequency with depth.

Regional dip is southeasterly and in the order of a few feet per mile. The formation is felt to be devoid of any faulting or folding in the immediate site area. The strata are considered to be nearly flat-lying with strike and dip values of no practical significance.

Isolated plateau remnants of flat-lying Tertiary strata in the southwest corner of the province suggest up to 2500 ft. of bedrock has been eroded from the damsite areas.[7] Much of this is undoubtedly due to preglacial subaerial erosion with lesser amounts due to subsequent glacial erosion. It is suggested that in preglacial times the Bearpaw shale formation was highly dissected, giving rise to a badland topography.

Significant postglacial physical disturbances suffered by the shale include early postglacial slumping along the valley and deep tributaries, a limited amount of present-day slope

Fig. 8. Regional Distribution of Surficial Deposits.

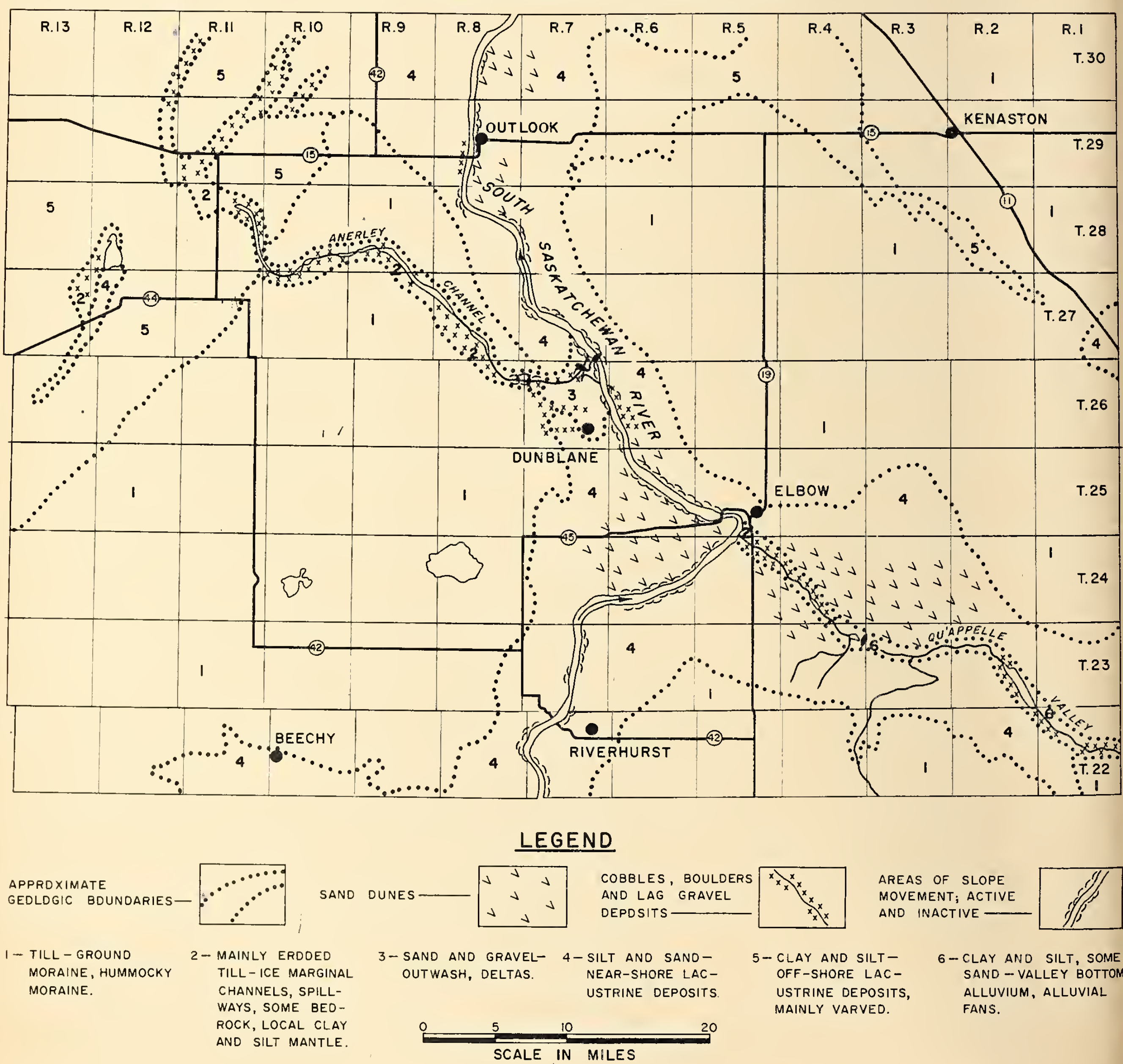


Fig. 9. Boulder-studded Till Erosion Surface in Coteau Creek Valley.

movement, and effects of near-surface weathering such as increased moisture content, loss of strength and decreased density. Engineering properties including rebound phenomena are well described by two previously mentioned papers by Peterson. [3,4]

Glacial Geology: Distribution of surficial deposits in the region of the sites is given in Fig. 8. The topographically high areas forming a major portion of the map-area are commonly glacial till. Areas lying at lower elevations including upland areas adjacent to the South Saskatchewan River Valley and the Qu'Appelle Valley are mainly glacio-lacustrine deposits of clay, silt and sand. These areas were the scenes of glacial lakes ponded against the ice front as it retreated to the northeast, which is the general direction of the regional dip of the land surface. More recently, many of the sandy deposits have been reworked by the wind into dunes.

Studies of the bedrock surface and depth of drift were made in the immediate site area by Mollard[9] and over a much wider area more recently by Scott.[10] Fig. 7, the profile of the west side of the site, shows a drift-infilled valley underlying Hudson's Bay Coulee (Stations 20+00 to 70+00). Mollard suggests this valley is of preglacial origin and that it continues southeasterly to intersect the Qu'Appelle Valley at a point some thirty-five miles distant. Scott's recent more regional work confirms the existence of this valley but indicates the valley likely originates at a point four miles north of Elbow and drains northwesterly. Present thoughts on the matter suggest there is meagre evidence of any major features of local preglacial drainage and that the valley is possibly an ice marginal channel of some ice sheet prior to the last.

The infilled valley underlying Hudson's Bay Coulee appears to represent the lowest local base level of erosion existing prior to the last glaciation. At least 80 ft. of gravelly sand lies in the gut, and this is overlain by approximately 100 ft. of till. In this valley east of the river, no substantial thickness of this gravelly sand strata overlies the bedrock, but the depth of till approaches 240 ft. Mollard[9] assigns a pre-Wisconsin date to the lower levels of the till deposit on basis of relatively high wet densities, that generally range between 138 to 145 lb. per cu. ft. Wet densities of the upper levels of the till deposit and nearby near-surface till normally range between 130 and 135 lb. per cu. ft. The older till seems to be characterized by an abundance of sand and gravel, occurring as seams, lenses, local pockets and even rather extensive beds. However these may be a result of deposition in a valley environment and may not be present to the same degree in the old till where it mantles upland areas.

Evidence of interglacial deposits separating the older till from the most recent is not well defined nor everywhere present. Evidence is cited by Mollard,[9] who interprets testhole data in the vicinity of Station 64+00, Fig. 7, to represent a northeasterly trending channel cut into the older till and bedrock and infilled with 80 ft. of sand and gravel, which in turn is overlain by the till of the most recent ice sheet. This ice sheet likely blanketed the entire area with till; evidence of thick deposits exists on the east side of the main valley and north of Coteau Creek Valley.

Postglacial Geology: The postglacial history of the area entails a relatively well defined succession of events of both erosion and deposition of vast volumes of sediments. In addition, during this period the site witnessed large-scale slope movement into the main valley and Coteau Creek Valley, abandonment of the Anerley Channel as a major drainage feature, and a reversal in direction of flow of the South Saskatchewan River. An end result is that construction materials of pervious and impervious fill, concrete aggregate and riprap are available in adequate quantities within noteworthy short hauling distances. However these same events also produced significant engineering problems that have required special consideration in the design of the dam. Outstanding of these are the control of seepage through approximately 100 ft. of river-deposited sands underlying the main fill, prevention of reactivated movement in now-dormant slump zones in the abutments, and control of seepage in various deltaic sediments in the upper portion of the west abutment.

Mollard[9] and Scott[10] support Edmunds[11] contention that the last ice sheet retreated locally in a northeastern direction, and that the ice front remained stationary for a considerable period along a line just northeast of the Anerley Channel, northeast of the river valley from the site upstream to Elbow, and northeast of the Qu'Appelle Valley. During this period, meltwater from the ice front north of the Anerley Channel and from stagnant ice on the hills south of the Anerley Channel, and later from glacial Lake Rosetown, which lay to the northwest, was channelled southeasterly along the ice front into the Qu'Appelle Valley.

The following chain of events is thought to represent the significant historical features of this particular period of the postglacial history in the site area.

1. Meltwater rapidly flowing along the ice front eroded a valley along its course to the southeast. An early phase of this valley is represented by a wide bench, studded with boulders and lying along the south side and to a lesser extent the north side of the Anerley Channel. Elevations range between 2000 and 2050, some 150 to 200 ft. above the floor of the Anerley Channel. The limit of downcutting by the meltwater and the probable end of this particular episode are marked by an extensive erosion surface now buried under 100 to 150 ft. of glacio-deltaic sediments on the west side of the site. Fig. 6 and 7 indicate that here the erosion surface, which is on till or bedrock, has an elevation of approximately 1750, suggesting that up to 100 ft. of till may have been eroded from this area. Fig. 9 shows a portion of the erosion surface exposed along Coteau Creek Valley. Southeasterly along the valley subsequent erosion has removed all but a few isolated remnants of this erosion surface.

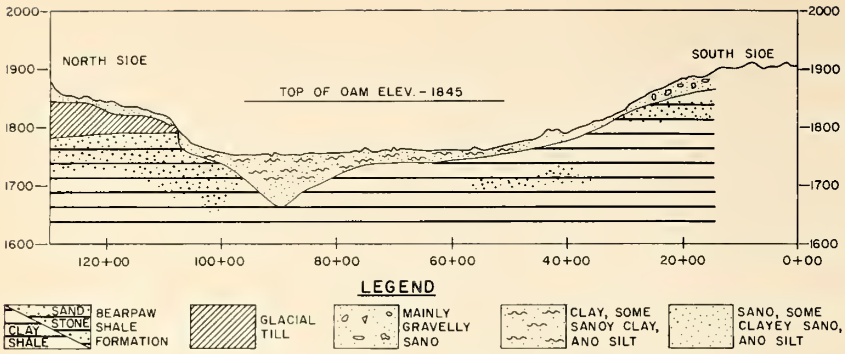


Fig. 10. Geologic Profile of Centerline—Qu'Appelle River Damsite.

2. The foregoing interval of erosion was followed by one of deposition. Flow of meltwater down the Qu'Appelle was dammed, or at least constricted, possibly by a local re-advance of the ice sheet. Glacial Luck Lake,[10] a northward extension of glacial Lake Beechy,[8] formed in the low-lying areas, and a large delta, covering some 15 square miles, developed over the triangular-shaped area now bounded by Coteau Creek, the South Saskatchewan River Valley and a line running southeasterly through Dunblane. Maximum lake level was in the order of 1950, as evidenced by elevation of the deltaic deposits and the lacustrine deposits east of the site. Fig. 7 shows that a depth of at least 200 ft. of gravelly sand was deposited as deltaic sediments on the erosion surface.

3. This episode was marked by resumption of flow down the Qu'Appelle Valley, a lowering of lake level, and erosion of a portion of the previously deposited deltaic sediments from the west side of the site. The initial fall in lake level caused meltwater flow across the delta to be concentrated to three main distributaries. One trended southeasterly through Dunblane; the second headed more easterly one mile north of Dunblane; the third had a northeasterly bearing across the immediate site area. Further lowering of the lake level saw a deepening of the most northerly channel and abandonment of the two southerly channels. Flow down the most northerly channel eroded all of the deltaic sediments from a triangular-shaped area, now defined by Coteau Creek, Hudson's Bay Coulee, and the South Saskatchewan River Valley. This area, locally known as the Plateau, is shown in Fig. 5.

4. Again, flow down the Qu'Appelle Valley was constricted and a ponded water environment prevailed in the site area. The level of glacial Luck Lake was much lower than that during the previous laking episode, and the lake was confined to the Plateau area and along the main meltwater channel to the southeast. Roughly 100 ft. of deltaic sediments of sand and gravel was deposited on the erosion surface at the apex of the delta (west end of the Plateau) and a similar thickness of interbedded clay and silt was deposited on the erosion surface in the deep water environment that existed along the eastern edge of the delta.

5. Resumption of flow down the Qu'Appelle Valley marks the beginning of this episode. Glacial Luck Lake began to drain and at the close of the episode had disappeared. During the fall in lake level, two deltaic distributaries developed. Their locations are now marked by Coteau Creek Valley and Hudson's Bay Coulee. Downcutting of these two channels continued to about elevation 1800, when flow down the Anerley Channel ceased. This abandonment of the Anerley Channel as a major outlet for glacial Lake Rosetown was caused by the creation of a lower northern outlet, uncovered by the ice sheet as it retreated to the northeast. The new outlet carried meltwater northeasterly and then southeasterly back to the site area to join up with the existing meltwater channel leading southeasterly and along the Qu'Appelle Valley.

Continued recession of the ice front to the northeast uncovered still lower areas that permitted the escape of meltwater to the east and north. Accordingly the southeastern flow of meltwater toward Elbow and down the Qu'Appelle Valley ceased. The Qu'Appelle Valley was also abandoned as a major drainageway by meltwater flowing easterly along the early South Saskatchewan River Valley in the Beechy area. This flow made an abrupt turn to the northwest in the vicinity of Elbow and flowed northwesterly past the site and along the course that was previously followed by meltwater flowing southeasterly.

Further retreat of the ice to the north and drainage of proglacial lakes permitted deepening of the valley by the river to elevation 1530 or thereabout in the site area. River downcutting was first in both till and shale, but from elevation 1560 to about 1530, all vertical erosion was likely in shale. During this time there was virtually no flow down Hudson's Bay Coulee. However, there was sufficient flow down the Coteau Creek Valley, mainly from local runoff and springs, to erode a deep, V-shaped valley with an accordant junction with the river. Stream gradient along the lower one and one-half mile reach was in excess of 100 ft. per mile. Mollard[9] suggests this downcutting stage precipitated wholesale slumping of the shale slopes along the lower reaches of the creek.

Testholes into the deep bedrock gut of the main valley reveal local deposits of up to 25 ft. of highly plastic clay overlying bedrock. This material may be of colluvial origin from the adjacent shale slopes or it may be a result of a "quiet-water" environment that may have prevailed when the river was at its lowest elevation. Regardless, deposition of this clay was followed by an extended period of alluviation during which up to 100 ft. of sand was deposited by the northerly flowing river.

Early stages of this period of river alluviation seem to have witnessed the sliding of considerable volumes of shale and till into the main valley from the east side. As far as is known to date, slope movement at this time occurred along a reach beginning at a point opposite Hudson's Bay Coulee and continuing north to a point just downstream of the main damsite. Fig. 6 shows roughly 15 ft. of river-deposited sand underlying the slide debris. The much greater thickness of sand overlying the debris must have been deposited after the slide occurred. This rather early date of movement is reflected in the air photo pattern, which shows only the faintest semblance of the characteristic surface expression of areas subjected to slumping. Other areas in the vicinity of the main damsite, such as on the east side downstream of the site, on the west side upstream of the site, and along the lower reaches of Coteau Creek, show surface indications of later movements. The air photos suggest the slope on the east side downstream of the main damsite has undergone the most recent movement or is moving at present. Here, evidence of old trails and fence lines that have been abandoned because of large cracks opening the ground surface suggests the movement is of a creep nature.

Other more recent geologic pro-

cesses might include the deflation of the sandy and silty lacustrine sediments on the east side roughly two miles upstream of the main damsite. Here, winds have scoured off several feet of sand and silt to reveal terrace gravels as well as the boulder-studded till erosion surface. The build-up of local dunes up to 5 ft. high accompanied the deflation.

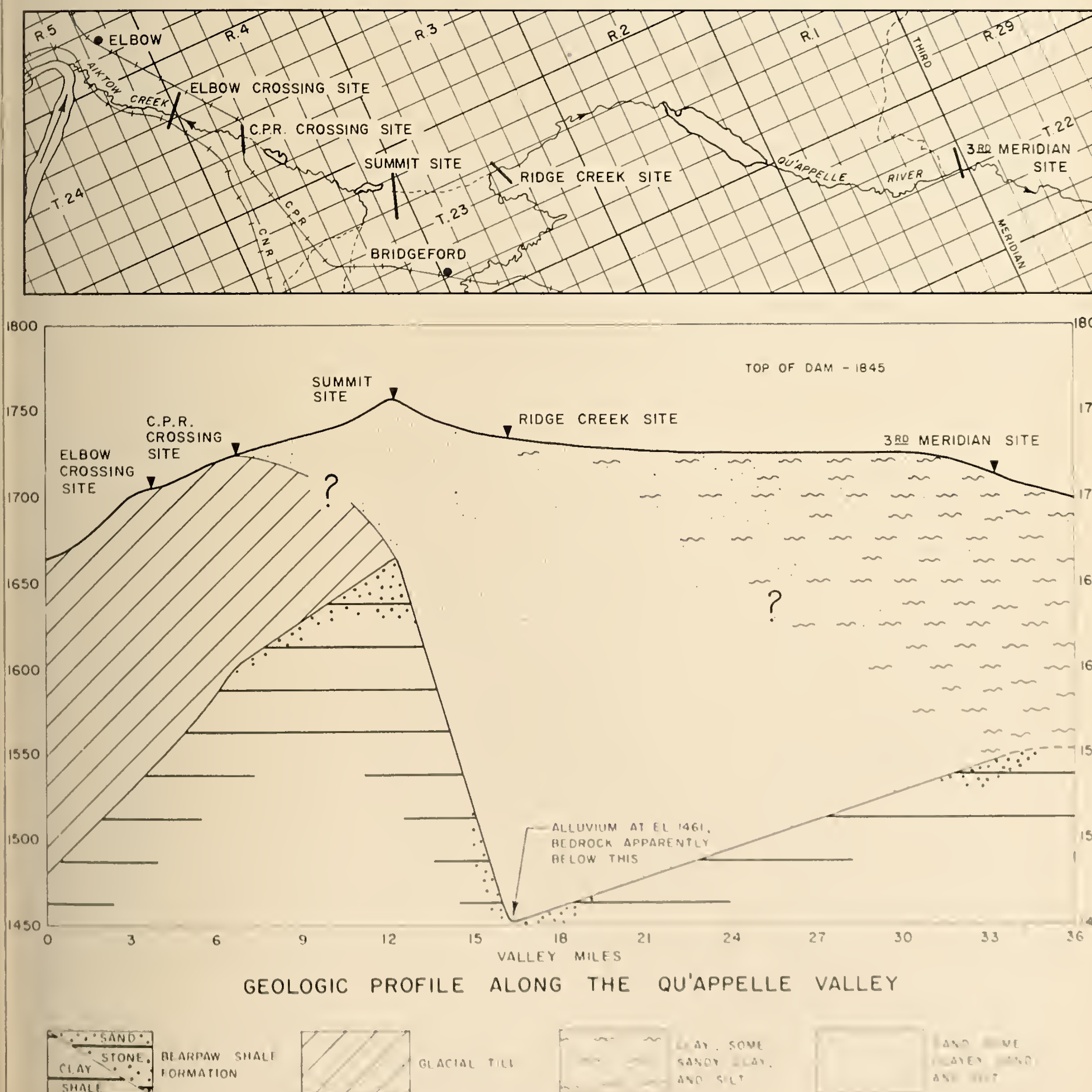
River Sand

A significant geologic feature influencing design of the main dam is the deep infilling of sand in the valley bottom. Early geologic intepretations of limited testhole data suggest the valley was eroded into bedrock to about elevation 1530 by an early ice sheet and was left infilled with ice, till, sand, silt, clay, and outwash resulting from the near-glacial environment.[7] The theory further suggests that most of these original deposits still remain in situ. Postglacial erosion is thought to have removed only a few feet of the material, which was more or less subsequently replaced by river aggradation.

Such an origin for the valley implies a rather heterogeneous, complex infilling, which could have considerable influence on the amount and location of seepage, and the type, depth and effectiveness of cut-off under the main dam. In 1951-52, a special testhole program was initiated to secure detailed engineering data on the valley infilling, particularly its permeability, density and shear strength. In addition, a detailed petrologic study was undertaken to parallel the engineering studies and to secure data on the geologic nature of the sediments.[12]

These later studies reveal the infilling to be mainly sand and considerably less heterogeneous than originally suspected. Sizes run between fine and coarse with both gravelly zones and clayey zones. Geologic studies on undisturbed samples reveal a fairly prominent current bedding structure with dips frequently ranging about 10° northerly. Conclusions indicate the bedrock gut of the valley was most likely eroded to its present elevation of about 1530 by postglacial river action, and that the valley subsequently underwent a prolonged and possibly uneventful period of aggradation by sands deposited by the north-flowing river.

Fig. 11. Map and Geologic Profile of Western Reach of Qu'Appelle Valley.



There must have been some period of time when the river flowed in the very bottom of the gut, and accordingly the adjacent steep shale slopes were exposed over their full height to a subaerial environment. Significance of this is that stresses tending to cause failure in these shale slopes were likely much higher at that time than they are at present. This theory on origin of the valley is further supported by the fact that a stratum of soft clay lies between the sand and shale at certain locations in the bedrock gut. The high moisture content and low density of the clay suggest it was never loaded by ice and was never subjected to a load much greater than that presently overlying it.

Geology of the Qu'Appelle River Damsite (Summit Site)

The Bearpaw shale formation underlying this site appears to incorporate considerably more sandstone and sandy shale than is present at the main damsite. The sandstone has a clay and silt content ranging between 25% and 70%; liquid limits range between 48% and 70%. The structure is very similar to that at the main damsite. The strata are felt to be flat-lying with no significant strike and dip values.

The bedrock gut underlying the valley alluvium extends downward to roughly elevation 1665. Fig. 10 shows the thalweg is located just below the north abutment. Contact between the bedrock and the overlying till in the north abutment is about elevation 1790, whereas the contact in the south abutment is about 1815. The north abutment is mantled by up to 15 ft. of dune sand and lies along the southern limit of a semi-stabilized dune area. The southern abutment appears to be covered by an erratically distributed deposit of sand and gravelly sand up to 15 ft. thick, which may represent a terrace deposit. At higher elevations back from the valley, this deposit disappears, and the till appears at the surface.

The material infilling the bedrock gut is thought to represent the eastern zone of the alluvial fan formed by Summit Creek where it enters the valley from the south. The material is mainly a uniform silty sand with local strata and zones of clayey sand and gravelly sand. The high sand content of the alluvium is likely due to the fact that Summit Creek passes through an active dune area just south of the valley. The dune area immediately north of the valley also has made a contribution of sand to the valley bottom sediments.

As mentioned previously, a total of five sites was investigated along the 34 mile reach of the Qu'Appelle Valley extending from Elbow easterly to the Third Meridian. Fig. 11 is a plan of this reach and a geological profile of the valley bottom as interpreted from the testhole investigations at the five sites. Early post-glacial history of the area suggests that an ice sheet located to the north diverted meltwater easterly down the Qu'Appelle Valley. When this sheet retreated northerly, lower outlets were uncovered to the north, and the valley was abandoned as a major drainage feature. Supposedly since that time, Summit Creek has been building up an alluvial fan in the valley bottom. Local drainage along the valley from the west has been insufficient to carry this debris away, and consequently the fan has become a drainage divide. Most of Summit Creek presently flows westerly, but there are surface indications, readily visible in air photos, suggesting easterly drainage in the past, possibly during times of flood.

The drainage along the valley for several miles west of the site is very poorly developed because of the very low gradient, little runoff, and the influx of dune sand blown into the valley from adjacent dune fields. However, in the vicinity of the Elbow Crossing Site, drainage to the west becomes better developed, and a narrow V-shaped valley leading into the South Saskatchewan River Valley has been eroded into the floor of the Qu'Appelle Valley by Aiktow Creek.

That portion of the valley between Elbow and the C.P.R. Crossing Site is floored by till with a thin mantle of sandy alluvium. At the Qu'Appelle River Damsite, some five miles east of the Crossing Site, roughly 100 feet of alluvium infills the bedrock gut. However at the Ridge Creek Site, four miles east of the Qu'Appelle River Damsite, the depth of sandy and silty alluvium overlying bedrock is at least 275 ft. Farther east along the valley the depth of alluvium decreases, and at the Third Meridian Site it is roughly 165 ft. Here the alluvium is mainly clay with a lesser amount of silty sand. It is remarkable the geology of a valley can vary so markedly over such a limited reach. An explanation of events leading to this particular situation awaits results of current, more regional studies by the Geological Survey of Canada and the Research Council of Saskatchewan.

Conclusions

This paper has attempted to familiarize readers with certain geologic aspects that have exerted varying degrees of influence on the preliminary site-selection program and, at a later date, on localized investigations of the damsites of the South Saskatchewan River Project. A particularly eventful period immediately following retreat of the last ice sheet resulted in deposition of a complex array of lacustrine, deltaic and fluvial sediments on till and on the Bearpaw shale formation in vicinity of the site for the main dam. The disposition of the sediments overlying the Bearpaw shale at the site for the Qu'Appelle River Dam is relatively straightforward; yet the sequence of events resulting in these deposits as well as those at other sites along the valley seems complex and is not yet fully understood.

Acknowledgements

Acknowledgment is made to G. L. MacKenzie, Director of P.F.R.A., for his permission to publish this paper. The writer is grateful to G. N. Munro, Chief Engineer, and R. Peterson, Chief Soil Mechanics and Materials Engineer, of the Engineering Services Branch, and to J. G. Watson, Project Engineer, and A. S. Ringheim, Materials Engineer, of the South Saskatchewan River Project, for their comments and kind assistance in preparation of this paper. The author is also grateful to L. C. Munn and B. J. Masley, P.F.R.A., and to Dr. J. S. Scott, Geological Survey of Canada, for their review of the paper.

References

1. MacKenzie, G. L. The South Saskatchewan River Dam. The Engineering Journal, May, 1960.
2. Berry, Wm. M., Durrant, E. F., and Booy, C. Hydrologic Investigations for the South Saskatchewan River Dam. A paper presented at the Engineering Institute of Canada Annual Meeting, 1960.
3. Peterson, R. Studies of Bearpaw Shale at a Damsite in Saskatchewan. Proceeding of the American Society of Civil Engineers. Volume 80, No. 476. August, 1954.
4. Peterson, R. Rebound in the Bearpaw Shale, Western Canada. Bulletin of the Geological Society of America. Volume 69, September, 1958.
5. Booy, C. The Structural Design of the Tunnels for the South Saskatchewan River Project. A paper presented to the Engineering Institute of Canada Annual Meeting, 1961.
6. Allan, J. A. Examination of Samples from Testholes. P.F.R.A. Files, July 21, 1944.
7. Allan, J. A. Origin of the South Saskatchewan Valley at Coteau Damsite No. 10. P.F.R.A. Files, Nov. 27, 1951.
8. Christiansen, E. A. Glacial Geology of the Swift Current area, Saskatchewan Department of Mineral Resources. 1959.
9. Mollard, J. D. Summary Report on Geology of the South Saskatchewan River Damsite, P.F.R.A. Files. Feb. 22, 1955.
10. Scott, J. S. Surficial Geology of the Elbow-Outlook area, Saskatchewan, Canada. Unpublished Ph.D. Thesis. University of Illinois. 1960.
11. Edmunds, F. H. Some Stages in the Recession of the Pleistocene Ice from Saskatchewan. Abstract Proceedings Royal Society of Canada. 3rd series, Volume 34, Appendix D. Sec. 4.
12. Edmunds, F. H. The Examination of Special Bore Holes at Site 10. Appendix 1, Summary Report on River Sand at Site 10. P.F.R.A. Files. March, 1953.

EIC

Design Considerations for LARGE RADIO TELESCOPES

J. L. Locke
Dominion Radio Astrophysical Observatory, Department of Mines and Technical Surveys, Penticton, B.C.

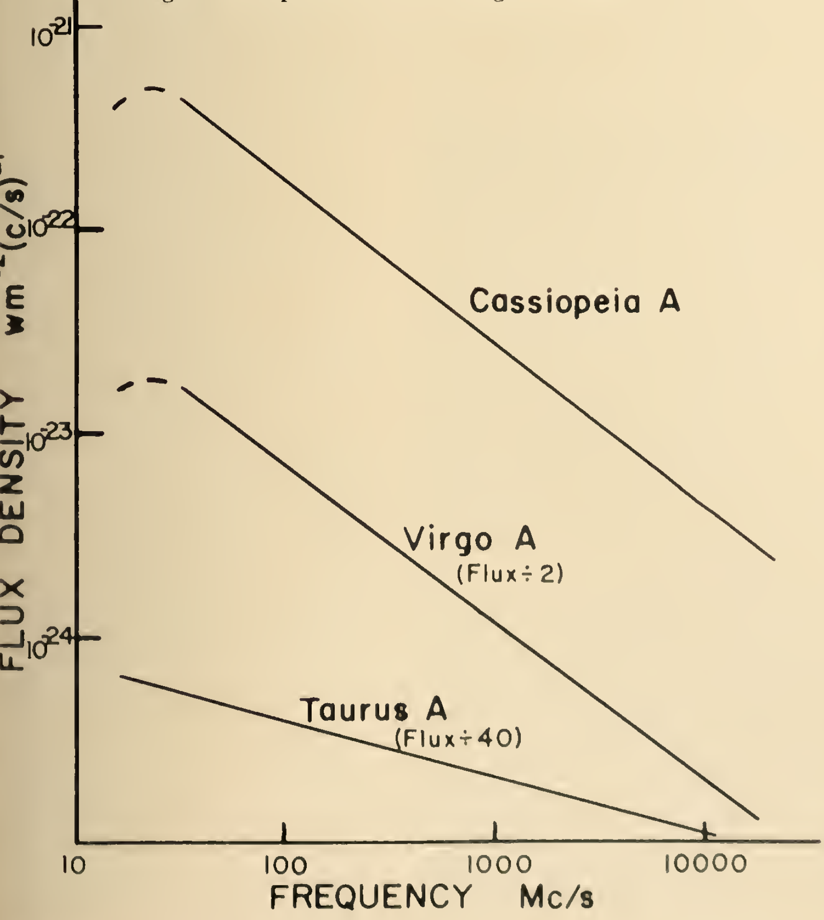
Presented at the 75th E.I.C. Annual General Meeting, Vancouver, May 1961.

RADIO ASTRONOMY involves the detection of extremely weak radio gnals from sources located at great istances from the earth. A radio tele-ope is essentially an antenna of high irectivity used in conjunction with a ensitive receiver for studying the in-ensity and distribution of these sources. he astronomical interest lies mainly in he fact that the distribution of regions f radio emission is dissimilar to that of he sources of light. The reasons for this ck of correspondence are now well nown. Firstly, in large regions of space om which there is little or no emission t optical wavelengths the physical con-itions favour the emission of energy at dio wavelengths. Some are regions of nized hydrogen (H II regions) while thers are regions where high velocity lectrons exist in the presence of a mag-etic field (synchrotron emission). econdly, attenuation of radiation by he gas and dust of interstellar space is small at radio wavelengths whereas it is high at optical wavelengths. Thus radio sources can be detected to much greater distances than optical sources. The radio observations are obviously complementary to the optical observations and it is, therefore, understandable that in recent years there has been interest in many countries in the construction of radio telescopes.

Whereas in the optical region of the spectrum the astronomer has a multitude of spectral lines to study, only one is known at radio frequencies. But the study of this one line, which is produced by neutral hydrogen, is of the utmost importance since neutral hydrogen, which occupies much of the interstellar space, does not emit at optical wavelengths. Radio methods permit extremely accurate determinations of frequency and hence the motions of celestial objects.

The major limitation of the radio telescope is its spatial resolution which is orders of magnitude poorer than the optical telescope. The resolving power of large optical telescopes is limited by atmospheric "seeing" but this limit has not yet been reached at radio wavelengths. Increased resolution is only achieved by increasing the size of the telescope. This paper deals with the problems involved in the construction of large radio telescopes. While many of the problems are the same as those for large antennae used for other purposes many arise from purely astronomical considerations.

Fig. 1. The spectra of three strong radio sources.



Types of Radio Telescopes

The two most important properties of a radio telescope are its angular resolution or beamwidth and its energy gathering power or effective area.

The angular separation, $\Delta\theta$, of two point sources of incoherent radiation which can just be resolved by a telescope (either radio or optical) is given by the relation

$$\Delta\theta = \alpha(\lambda/D) \text{ radians} \qquad (1)$$

where D is the linear dimension of the aperture, λ is the wavelength in the same units as D and α is a constant near unity. For a uniformly illuminated rectangular aperture $\alpha = 1$ and for a circular aperture $\alpha = 1.22$.

From (1) it is evident that to achieve the same resolving power, a telescope for use at $\lambda = 10$ metres (30 Mc/s) must have linear dimensions 1000 times greater than a telescope for use at 1 cm. To have a resolving power equal to that of the unaided eye (1′ of arc) a telescope for use at 10 metres must have an aperture of about 35 kilometres. Even at $\lambda = 1$ cm. an aperture of about 35 metres is required.

If the radio flux to be measured is sufficiently large it is not necessary to completely fill the aperture to achieve the desired resolving power. Fortunately this is the case at long wavelengths and as a result a variety of interferometric techniques have been used.[1] At Cambridge very large apertures have been synthesized by combining in amplitude and phase, observations taken with a two-element interferometer, one element of which is moved to different positions.[2] The resolution obtained is equivalent to that which would have been obtained with a single large antenna, although the individual signal levels are lower.

At short wavelengths these techniques can no longer be used except for the strongest sources. The flux from celestial sources of radio energy may be represented by the relation

$$W \propto \lambda^x \qquad (2)$$

where the spectral index, x, is a positive number. For the radiation from the galaxy $x = 0.37$[3] and for other sources the spectral index varies from about 0.3 to 1.8.[4] The flux received from all sources at short wavelengths is thus considerably less than that received at long wavelengths. Also, the sensitivity and stability of present-day receivers for the shorter wavelengths are normally lower than those for long wavelengths. It, therefore, becomes imperative to utilize the full aperture.

To further increase the sensitivity it is necessary to integrate the receiver output over a considerable interval of time. The diurnal motion carries a point on the celestial equator through the beam of a telescope with a beamwidth of 1' of arc in four seconds of time. Since integration times in excess of 100 seconds are often required it is desirable that the telescope be capable of "tracking" or "guiding on" a celestial object. The integration can of course be performed by combining successive records but this is not usually convenient.

The design which most easily satisfies these requirements is the parabolic reflector. The paraboloid is mounted so that it can be rotated about perpendicular axes. The reflector focusses the radiation on a small antenna or "feed" at the focus of the paraboloid. This type of telescope has the additional advantage that it is broad-banded or achromatic so that the frequency response is limited only by the feed, which is usually a narrow band device. When a change of operating frequency is required it is a simple matter to change the feed. In some cases several feeds have been mounted at the focus and used simultaneously.[5]

The Parabolic Radio Telescope

(a) *The reflecting surface:* As is the case for mirrors of optical telescopes the surface of the radio telescope must conform to a true paraboloid of revolution to an accuracy of better than a quarter of a wavelength if the theoretical resolution is to be realized. It is customary to specify that the errors not exceed an eighth of the shortest wavelength to be used. Thus for a telescope to operate at the important wavelength of 21 centimeters the maximum departures allowable are approximately 1 in. The U.S.S.R. has recently announced the construction of a steerable parabolic telescope 22 metres in diameter with surface errors less than 0.8 mm. This telescope has been tested at a wavelength of 8 mm. where it has a resolution of 1.'8 of arc.[6]

It is to be noted that the required accuracy of the surface is independent of the size of the aperture. As the size of the telescope is increased it becomes increasingly difficult to achieve the necessary accuracy for all orientations of the telescope and conditions of wind loading. For extremely large telescopes it will become impractical to build structures of sufficient rigidity and it will be better and less expensive to continuously monitor the figure of the dish and apply corrections by a servo system. The monitoring may be accomplished by an optical method or by a radio reflection technique as has been suggested by Swarup and Yang.[7]

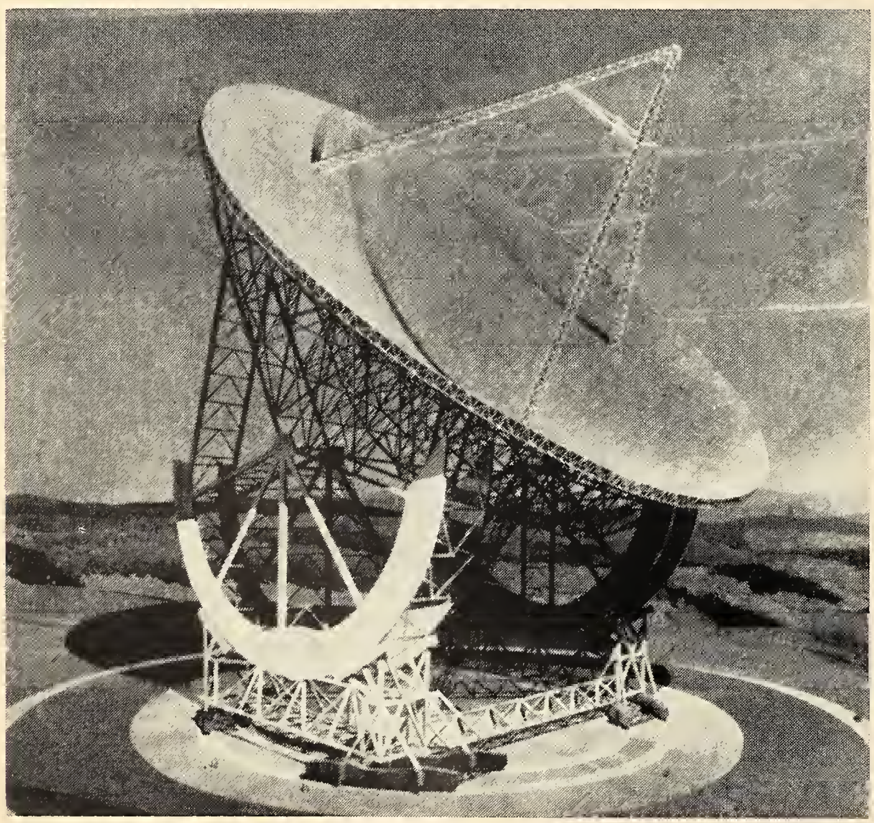
It is difficult to define uniquely the optimum ratio of the focal length of the paraboloid to the diameter of the aperture (F/D ratio). Normally it is less than 0.25, i.e., the focal lies outside the aperture plane. A small F/D ratio has the advantage that the amount of radiation reaching the feed from the ground or other sources beyond the edge of the dish (spillover radiation) is reduced. It is, however, difficult to design feeds, especially the horn type feeds employed at short wavelengths, which adequately "illuminate" the entire area of the paraboloid. Focal ratios in the range 0.25 to 0.5 have usually been used, the exact value seeming to be a matter of personal preference.

The surface of the paraboloid may be a mesh of conducting material rather than a continuous sheet provided that the holes are a small fraction of a wavelength. The transmission of the mesh is small if the diameter of the holes is less than one-eighth of the wavelength used. However, it should be mentioned parenthetically that at short wavelengths the radiation from the warm ground is considerably greater than that from the sky so that even a small percentage transmitted by the surface of the dish may not be negligible. As receiver design improves and the noise produced in the receiver itself is decreased the contribution due to transmitted ground radiation will become more important. These remarks apply also to the "spillover" radiation mentioned above.

(b) *Type of Mounting:* There are two basic types of mount—the equatorial or polar axis mount and the altitude and azimuth (alt-azimuth) mount. The equatorial mount has the obvious advantage that the tracking of a celestial object requires merely a rotation of the telescope about the polar axis at the constant rate of 1 revolution per sidereal day. The tracking can thus be achieved with a synchronous motor. For this reason the equatorial mount is the obvious choice for small or medium-size radio telescopes.

As the diameter is increased, the equatorial mount becomes mechanically difficult and serious overhang problems arise. In the polar mounting the gravity deformations of the dish are a function of

Fig. 2. An artist's conception of the 600-foot radio telescope under construction for the U.S. Navy at Sugar Grove, West Virginia — an example of the alt-azimuth type of mounting.



oth altitude and azimuth whereas in he altitude-azimuth type of mounting he gravity deformations are single-alued functions of altitude only and ompensation is more easily obtained. t has been estimated that the increased roblems involved in the polar mount ecome excessive at about a diameter of 50 ft.[8] It is likely, therefore, that all elescopes larger than 150 ft. will be lt-azimuth mounted.

The alt-azimuth mounting requires ome form of coordinate conversion com-uter to effect the tracking of celestial bjects. This computer can be of the nalogue type consisting essentially of a aster equatorial drive with servo enerators on the appropriate axes. The ew 210 ft. radio telescope now nearing ompletion in Australia incorporates a ovel design in which the master equa-orial consists of an equatorially mounted ptical telescope at the centre of rota-ion of the dish.[9] A light source mounted n the dish itself projects a light beam nto the telescope. A photo-electric ystem produces an error signal to drive he azimuth and altitude motors when he light source does not lie on the optic xis of the telescope. (Fig. 4.)

(c) *Pointing Accuracy:* When a source f radio emission passes through the entral lobe of the radio telescope it is ossible to determine the position of the aximum of the recorded profile to etter than about 1/20th of its half-idth. For a source of small angular xtent this half-width will be very nearly qual to $\Delta\theta$ given by (1). Thus the aximum driving and read-out error hould be given by

$$\text{Max. pointing error} < (\lambda/20D) \text{ radians} \quad (2)$$

or an 84 ft. telescope operating at 21 m. the maximum allowable error from 2) is approximately 1.5′ of arc.

As the diameter is increased it be-omes increasingly difficult to achieve he additional accuracy required by (2). or very large telescopes to be used at hort wavelengths it is unlikely the esired accuracy can be obtained in the riving gears and bearings. A master-lave system such as is employed in the ustralian telescope would appear to be he obvious solution to this problem.

The foundation and support tower ust, of course, be sufficiently rigid to aintain the axis alignment to the same olerance. It is desirable to paint ex-osed surfaces with reflecting paint to educe the effect of differential solar eating of the support structure.

The feed antenna must be rigidly ounted at the focal point of the para-oloid so that its position does not hange with orientation. Usually the eed is mounted on a tripod or quadru-od constructed of dielectric material

Fig. 3. The Dominion Radio Astrophysical Observatory near Penticton, B.C. The 84-foot paraboloid is equatorially mounted.

anchored in the framework of the dish, although a single guyed mast has been used.[10] Since the supporting spars will have a small effect on the shape of the antenna beam it is probably preferable for polarization experiments to have a support which is symmetric about a line in the aperture plane.

To preserve the phase relationship of the waves reflected from the dish the feed must not move along the axis of the paraboloid more than a fraction (say 1/10th) of the wavelength used. A dis-placement in the perpendicular direction will result in a pointing error. Thus the maximum departure must be such that it subtends an angle at the vertex of the dish substantially less than the error in pointing of the dish.

(d) *Sky Coverage:* It is not strictly necessary for the telescope to be capable of pointing down to the horizon at all azimuths. Near the horizon the effects due to atmospheric refraction and ground radiation make observations difficult so that it is advisable to wait until the object is near maximum elevation. When the telescope must be located at high latitudes, as in Canada, it is desirable that the telescope be able to reach down close to the southern horizon, otherwise objects at southern declinations will be unobservable. The centre of our galactic system which is an interesting region for astronomical studies reaches a maxi-mum altitude of about 15° above the southern horizon at a latitude of 45°N.

The arguments notwithstanding, it will always be desirable to have com-plete sky coverage whenever this can be achieved without undue cost or sacrifice of accuracy.

(e) *Feed:* The purpose of the feed antenna is to receive the radiation re-flected to it by the paraboloid. For a point source of emission maximum signal will be produced at its output terminals if its response is uniform over the angles subtended by the dish and zero every-where else. Usually the terminology of a transmitting antenna is used, in which case the feed is said to uniformly il-luminate the dish. A feed with these characteristics is not only impossible to construct but is not the most desirable for a radio telescope. The secondary or side lobes of such a telescope would be given by the diffraction theory for a uniformly illuminated aperture; that is, a central lobe with diffraction rings and, although the amplitude of these rings is small, they accept radiation from large areas of sky. By proper choice of the illumination "taper" it is possible to greatly reduce the intensity of the side lobes at the expense of broadening the main lobe only slightly. A compromise usually has to be reached between re-solving power on the one hand and magnitude of side lobes and spillover on the other.

Sites for Radio Telescopes

Although of a different nature, the requirements for the site of a radio ob-servatory are as stringent as those for an optical observatory. Since the signals from celestial sources, with the exception of the sun, are exceedingly weak, a site is required which is as free as possible from radio interference. For observa-tions of the continuum radiation a broad bandwidth is required, but since there are no sharp features (other than the 1420 Mc/s hydrogen emission), the

centre frequency need only fall within a rather broad region of the spectrum. Only in the crowded regions of the radio spectrum will broadcast transmitters create a serious problem. However, interference generated by sparking in electrical equipment and automobile ignition systems, corona discharge from high tension electrical power lines and the like are broad-banded and hence cannot be avoided by choice of operating frequency. If the lowest interference level is to be achieved, the observatory must be located some distance from centres of population. At the higher frequencies a measure of protection can be obtained by locating the observatory in a valley since the surrounding hills will act as a shield for line-of-sight transmissions. If these precautions are not taken a radio observatory may, in a few years, find itself in the position of optical observatories which are frustrated by the encroachment of the lights of the expanding city. As the sensitivity of receivers is improved the interference level of the site may well be the factor limiting the minimum detectable signal strength.

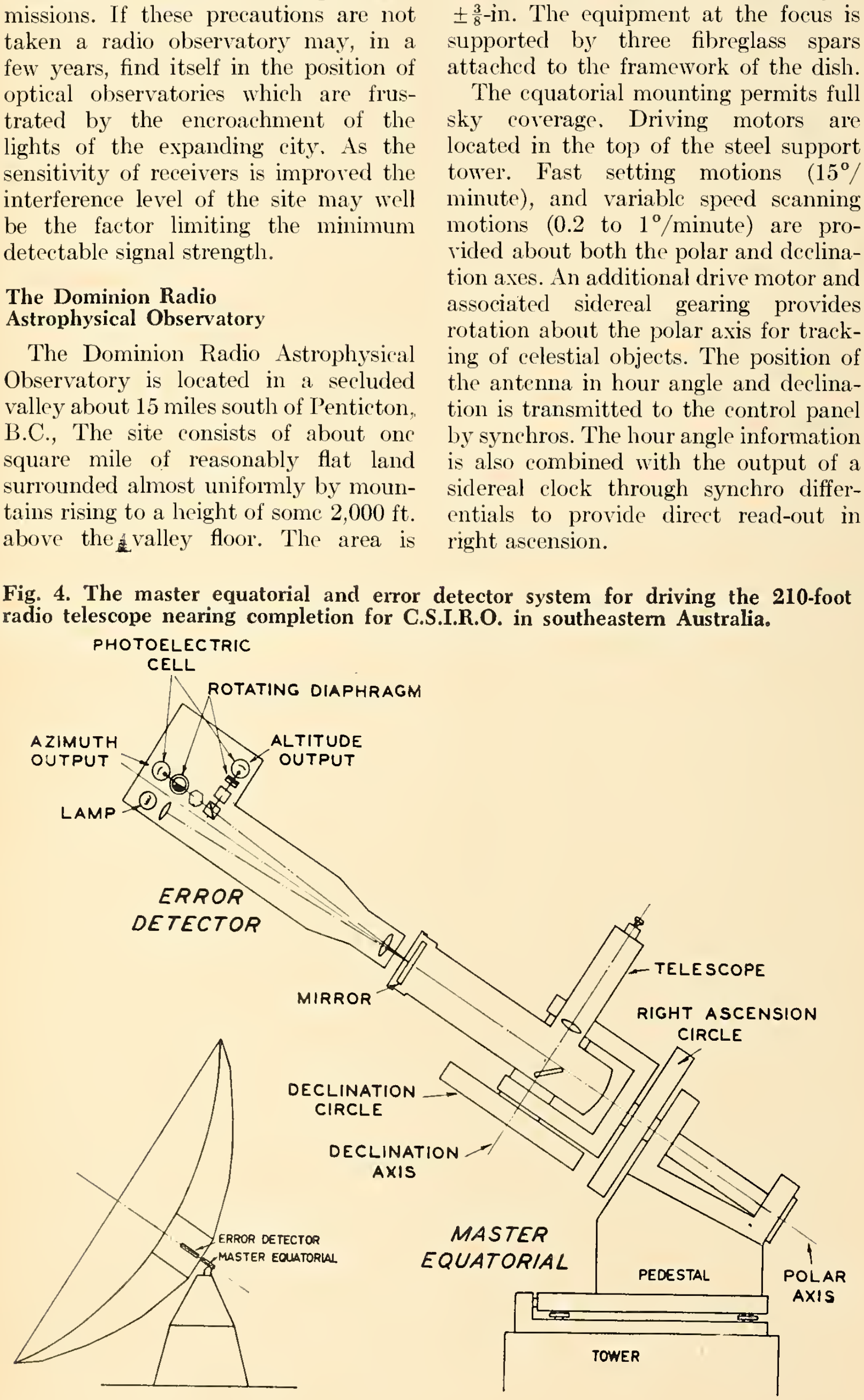
The Dominion Radio Astrophysical Observatory

The Dominion Radio Astrophysical Observatory is located in a secluded valley about 15 miles south of Penticton, B.C., The site consists of about one square mile of reasonably flat land surrounded almost uniformly by mountains rising to a height of some 2,000 ft. above the valley floor. The area is sufficiently large to permit the erection of low frequency antenna arrays in the future.

The equatorially mounted parabolic telescope (Fig. 3) was designed and constructed by an American company. Since the initial programs of the observatory are concerned with the 21 cm. hydrogen emission the maximum tolerances specified were appropriate to this wavelength, as developed above. The aperture of this telescope is 84 ft. in diameter and the focal length 25 ft., making the focal ratio approximately 0.3. The dish consists of 80 pre-fabricated sections, each constructed of aluminum tubing in a network truss system. The reflector surface is $\frac{3}{8}$-in. aluminum mesh. The reflector surface accuracy is $\pm\frac{3}{8}$-in. The equipment at the focus is supported by three fibreglass spars attached to the framework of the dish.

The equatorial mounting permits full sky coverage. Driving motors are located in the top of the steel support tower. Fast setting motions (15°/minute), and variable speed scanning motions (0.2 to 1°/minute) are provided about both the polar and declination axes. An additional drive motor and associated sidereal gearing provides rotation about the polar axis for tracking of celestial objects. The position of the antenna in hour angle and declination is transmitted to the control panel by synchros. The hour angle information is also combined with the output of a sidereal clock through synchro differentials to provide direct read-out in right ascension.

Fig. 4. The master equatorial and error detector system for driving the 210-foot radio telescope nearing completion for C.S.I.R.O. in southeastern Australia.



A 10-in. optical telescope is mounted with its optic axis parallel to the electrical axis of the radio telescope and looks out through a hole in the dish. The telescope may be used for checking the accuracy of the driving mechanism or for guiding the radio telescope on objects such as planets which do not move at the sidereal rate. A control station near the eyepiece of the telescope enables the observer to control the motion of the driving motors.

The feed for the hydrogen line studies is a broad-band horn, designed and constructed by the Radio and Electrical Engineering Division of the National Research Council.[11] The receiver for this work is a Dicke type comparison radiometer with synchronous load and detector switching. Originally the comparison was achieved by switching at the input to the I.F. amplifier but now the switching is accomplished by a crystal diode switch operating at signal frequency. The switch, reference load, crystal mixer and the first stages of the I.F. amplifier (35 Mc/s) are mounted behind the horn. Tuning is accomplished by changing the first local oscillator frequency. Filters at the second I.F. frequency (10.7 Mc/s) permit a choice of bandwidths from 2 kc to 6 Mc/s.

Since coming into operation the observatory has been concerned with detailed studies of the distribution and velocities of neutral hydrogen in our galaxy, notably in those regions where associations of hot O and B stars are located. To increase the sensitivity a parametric amplifier will be installed and tested on the telescope in the near future. Long range plans call for the installation of a low frequency (about 20 Mc/s) array on the same site for continuum studies of the galactic system.

References

1. Pawsey, J. L., and Bracewell, R. N. Radio Astronomy; Clarendon Press, Oxford.
2. Ryle, M. and Hewish, A. The Synthesis of Large Radio Telescopes; Monthly Notices of R.A.S., 1960, vol. 120, 220.
3. Costain, C. H. The Spectrum of the Galactic Radio Emission; Monthly Notices of R.A.S., 1960, vol. 120, 248.
4. Kellermann, K. I. and Harris, D. E. 960 Mc/s Observations of Radio Sources in the Sydney Catalogue; Obs. of C.I.T. Radio Observatory 1960, No. 7.
5. Jasik, H. A Wide-Band Antenna System for Solar Noise Studies; Proc. I.R.E. 1958, vol. 46, 135.
6. Vitkevich, V. V. Report presented to XIIIth General Assembly of U.R.S.I., London 1960.
7. Swarup, G. and Yang, K. S. Monitoring Parabolic Reflector Antennas; Proc. I.R.E. 1960, vol. 48, 1918.
8. Emberson, R. M. and Ashton, N. L. The Telescope Program for the National Radio Astronomy Observatory at Green Bank, West Virginia; Proc. I.R.E. 1958, vol. 46, 23.
9. Bowen, E. G. Problems Involved in the Design of a Giant Radio Telescope; The Australian Engineer, Feb. 1960, 45.
10. Schor, R. J. De Constructieve Uitvoering van de 25M Radiotelescoop; De Ingenieur (The Netherlands) 1957, No. 3.
11. Millar, R. F. A Horn Feed for an 84-foot Paraboloid; N.R.C. Report ERB-533, Jan. 1960.

POWER STATION FEED HEATERS

J. V. Bigg, M.A., A.M.I. MECH.E.

*Div. Asst. Chief Mechanical Engineer,
Auxiliary Apparatus, Turbine-Generator Division,
Associated Electrical Industries Export Ltd.,
Trafford Park, Manchester, England.*

T IS more than 40 years since the first feed-heating system for land ower stations was installed in Britain, though this installation had been receded for some time by the use of ed heaters in marine work.

The present state of the practice f feed heaters is however, much re-ioved from the relatively simple quipment of those days, and this aper is an attempt to present a brief irvey, firstly of some of the perform-nce considerations involved, and econdly of several of the detail fea-ures and construction problems in-olved in present-day plant.

There exists a very comprehen-ve literature which covers in detail any of the factors which enter into e design of a feed heater, and a ibliography in the Appendix lists me of this information.

No attempt has been made to eal fully with every aspect of the de-gn and construction problem. Detail escription has been confined to those ems where existing literature is anty and where the author feels at information of interest can be resented.

etermining the Appropriate Feed rain

From theoretical considerations it ould be desirable to have an in-inite number of feed-heating stages, ut obviously this is an ideal that ust be modified by consideration of onomics and practical possibilities. The number of tapping points which can conveniently and economically be arranged in the turbine cylinder or cylinders is the first restraining factor; this may vary from one or two in small machines to seven or eight in large. The starting point in the design of the feed system is to determine the number of feed heaters and the individual performance required from both the thermal and hydraulic standpoints. This necessitates consideration of the overall cycle, including the economic final feed temperature, and the individual heater terminal differences and pressure drop.

The feed-heater designer has thus a framework of requirements on which he can commence operations. Continued co-operation between the heater designer and the turbine designer is still vital, particularly regarding the question of the most economic form and magnitude of surface of feed heaters.

The relative importance of the feed heating train in the overall turbine/boiler cycle is illustrated by a number of sketches No. 1 to 5.

These have been prepared to cover a range of five sizes of set up to 300 Mw., for typical U.K. conditions; this range is regarded as sufficiently representative to show the trend.

Figure 1—Illustrates the proportion of station thermal efficiency due to feed water heating. The station average overall thermal efficiency is on the basis of sent out units. These figures are arrived at by considering the difference in heat rate of the cycle under feed heating conditions, compared with non-feed heating, assuming boiler efficiency remains the same. The deaerator is included as part of the feed heating system. It should be realised that these figures are representative of average British practice over the past years and do not necessarily represent the maximum exploitation of feed water heating, which could be justified by other economic conditions and fuel costs.

Figure 2—Shows the heat transferred to the feed water expressed as a percentage of the heat equivalent of the sent out units. The quantity of heat transferred by de-superheating is shown separately.

Figure 3—Shows typical percentage of surface in feed heaters used for desuperheating. In the examples shown, feed heater surface specifically arranged and included for desuperheating is not commonly incorporated in the feed heater nest below the 100 Mw. rating.

Figure 4—Illustrates the hydraulic pumping power absorbed in transferring this heat. As can be seen it is less than four kw. per Mw sent out for all sizes of sets. The head loss shown is confined to that incurred in pumping the feed water across the actual heat transfer surface (both low-pressure and high-pressure) and does not include pipe loss etc.

ig. 1. Proportion of Station Thermal fficiency due to Feed Heating.

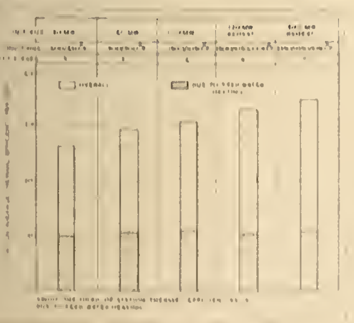


Fig. 2. Heat transferred by feed water heating as a percentage of heat equivalent of power output.

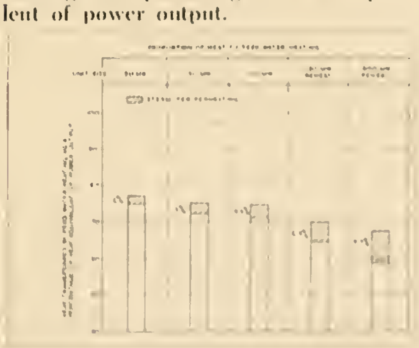


Fig. 3. Typical percentage of surface in feed heaters used for desuperheating.

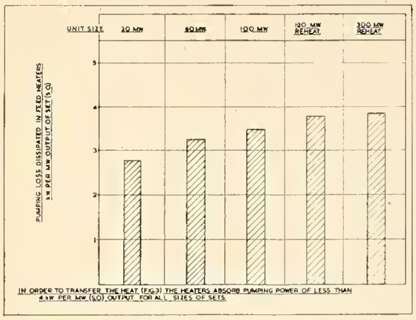


Fig. 4. Pumping loss dissipated in feed heaters.

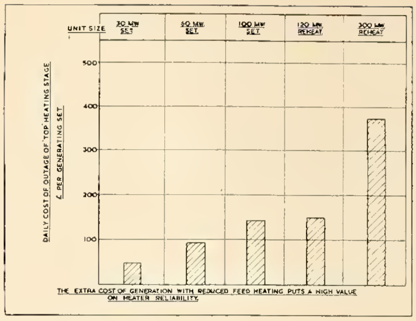


Fig. 5. Daily cost of outage of 'top' heating stage in £ per generating set.

Figure 5—Illustrates the daily cost of outage of the highest condition feed heating stage in £ per set due to thermo-dynamic loss, and illustrates the high value which can be placed on feed heater reliability. The figures are based on average U.K. heat rates, a 24 hour day at 100% load, and a fuel cost of about 45d per 10^6 B.t.u.

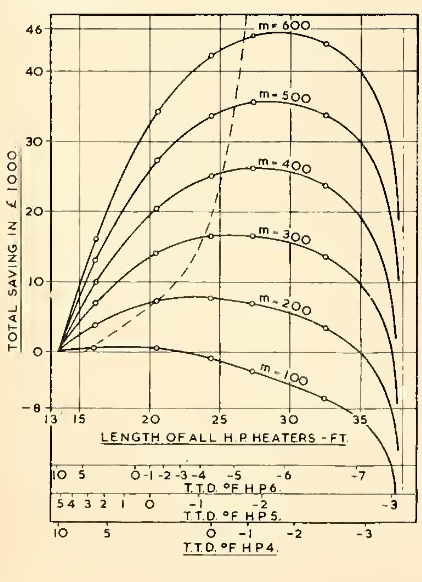
The Economic Size of Heater

The terminal temperature difference of a feed heater, by which conventional term is meant the temperature difference between the saturation temperature of the steam supplied to the heater, and the outlet feed from the heater, is directly related to the surface, and hence cost, of the heater.

In general, the increase of surface with reduction of terminal temperature difference is asymptotic.

It is, however, possible to make an investigation into the economic size of feed heaters under given conditions in the following manner. The increased cost of providing the extra heater surface is balanced against the capitalized value of the improved performance gained by such extra surface.

Fig. 6. Curves showing the economic size of feed heaters for various operating conditions.



This exercise can be done for both low-pressure and high-pressure heaters. A typical set of curves showing the results of one such investigation covering the three high-pressure heaters on a 100 Mw. set with steam conditions 1500 p.s.i.g., 1050°F is shown in Fig. 6.

It will be noted that terminal temperature differences (T.T.D.) for the three heaters are shown separately, and that a family of curves for varying 'm' factors has been drawn. The operation factor 'm' has been used as a method of presenting the information to cover various operating cost conditions, and is made up as follows (1*, etc.,)

$$\text{operation factor m} = \frac{F}{H/10{,}000} \times \frac{L}{r}$$

where F is fuel cost, shillings/ton; H is calorific value of fuel, B.t.u./lb. L is load Factor, percent; and r is rate of capital charges including maintenanee and attendance.

For an 'm' factor of 100 it can be seen that no significant gain is obtainable by increasing the size of high-pressure heaters above that necessary to obtain a T.T.D. of about 10°F. The dotted curve is drawn through the sizes of heater appearing to give optimum return at the various 'm' factors. All heater nest lengths have been kept constant for purposes of interchangeability.

To present such information in compact form, a considerable amount of detail work is necessary, and certain factors have to be oversimplified, but once the exercise has been carried out for several representative cases, a general picture can be built up to give a good guide to the consideration of the economics of individual feed-heating sehemes.

Thermal Design of Feed Heaters

The feed system is conventionally divided into low-pressure and high-pressure portions, the low-pressure portion being normally that from the extraction pump discharge up to the boiler feed pump or lift pump, and including the deaerator if fitted. The high-pressure portion is that after the feed or lift pumps.

When considering the design of feed heaters it is convenient to divide them into low-and high-pressure groups, as the two types have many differences.

Low-Pressure Heaters

The design of low-pressure feedwater heaters is in many respects a relatively straightforward task compared with those of the high-pressure group, although some of the factors of detail construction discussed in the latter part of this paper also apply. The mechanism of heat transfer, since the bled steam will contain little or no superheat, can be regarded as straightforward condensation. Heat transfer rates appropriate to the condensation of steam in low-pressure heaters are shown in Fig. 7.

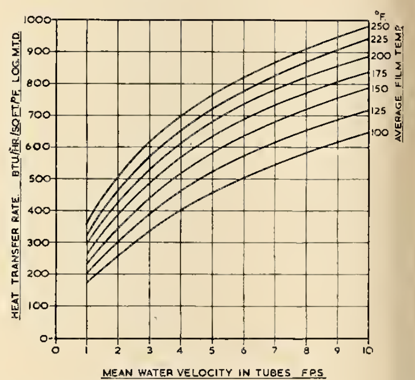


Fig. 7. Overall heat-transfer rates for bled steam feed heaters.

From economic considerations a low-pressure heater is usually designed to have a terminal temperature difference between outlet feed and saturated steam temperature of 10°F or less. It will be found that in practice it is extremely difficult to approach a terminal temperature difference less than 2°F. In addition to the provision of adequate surface, the design of the heater on the steam side is therefore concerned only with baffling adequate to give proper tube support, to permit steam flow to all parts of the nest, and with the appropriate venting arrangements to avoid the possibility of residence in the heater of pockets of incondensables which would both blanket otherwise useful condensing surface and cause corrosion. A typical low-pressure heater representative of modern practiee is shown in Fig. 8. It will be observed that precautions are taken against impingement ero-

*A numerical list of references is given in the Appendix.

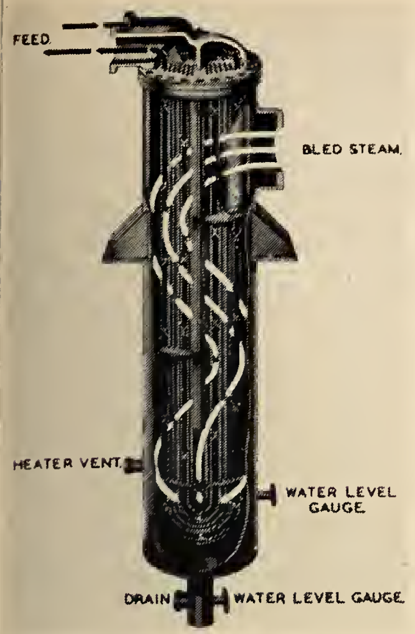


Fig. 8. Sectionalized view of typical low-pressure feed heater.

sion of the tubes at the steam inlet by the fitting of a baffle, that the tubes are of the hair-pin type, to permit differential expansion between tubes and shell, that the tubes are fixed in the tube plate by roller expanding and that the scantlings of the tube plate, header, and bolting are relatively light.

Drainage of Heaters

In any system of feed heaters, adequate methods must be employed to drain the condensed steam from each heater shell, and recover as much heat from these drains as is economically desirable before the drain is rejected to the final sink of the condenser. The practice of draining from a heater at higher pressure directly into the shell of one at lower pressure is to be avoided, as this can complicate the design of the lower pressure heater in avoiding shell corrosion and air blanketing. A satisfactory solution is to have flash boxes, in parallel with the heater spaces, receiving drains from heaters at higher pressure and venting into the bled-steam line to the heater with which it is associated. The drain from any heater shell and the flashed drain from the associated flash-box are both led to the next lower stage flash-box. By this means the heater design is simplified and a potential source of trouble is removed. Residual heat from the accumulated drains of a number of heaters can be transferred to the feed water, if economically justifiable, by allowing such drains to be taken to a drain flash condenser (D.F.C.) before they pass to the main condenser. This D.F.C. is similar in construction to a low-pressure heater, and may in fact be incorporated with it on a common header as shown in Fig. 9.

High-Pressure Heaters

The rapid increase in the size of turbine-generator units throughout the world and the use of ever higher boiler conditions in the search for improved thermal efficiency have brought many new problems to the design of high-pressure feed heaters. With the low-pressure section of the feed train the change has been largely one of increase in size and relatively slight increase in operating pressures due to increased numbers of units in the feed train and the raising of deaerator operating pressures and temperatures. But with high-pressure heaters, especially if connected to the boiler feed-pump discharge, the operating pressures have increased swiftly, as have the operating temperatures of the heater due to higher conditions in the tapped steam, irrespective of whether a split pumping system is involved or not.

With the advent of bled steam of high temperature it has become economically necessary to take advantage of the often considerable amounts of superheat which this steam contains, to decrease the terminal difference, and consequently the conception of heat transmission on the steam side of the heater has to cater for such circumstances.

It will be realized therefore that with appreciably superheated steam entering a heater, desuperheating has to take place before condensation occurs. The arrangement of heater surface and baffling must therefore take account of this, and that portion of the heater next which the steam first traverses must be designed on the basis of convective heat transfer from a gas (the superheated steam) to the surface of the tube and be

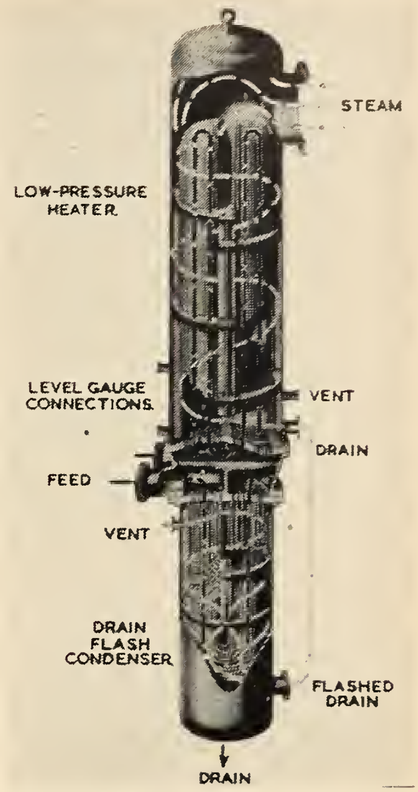
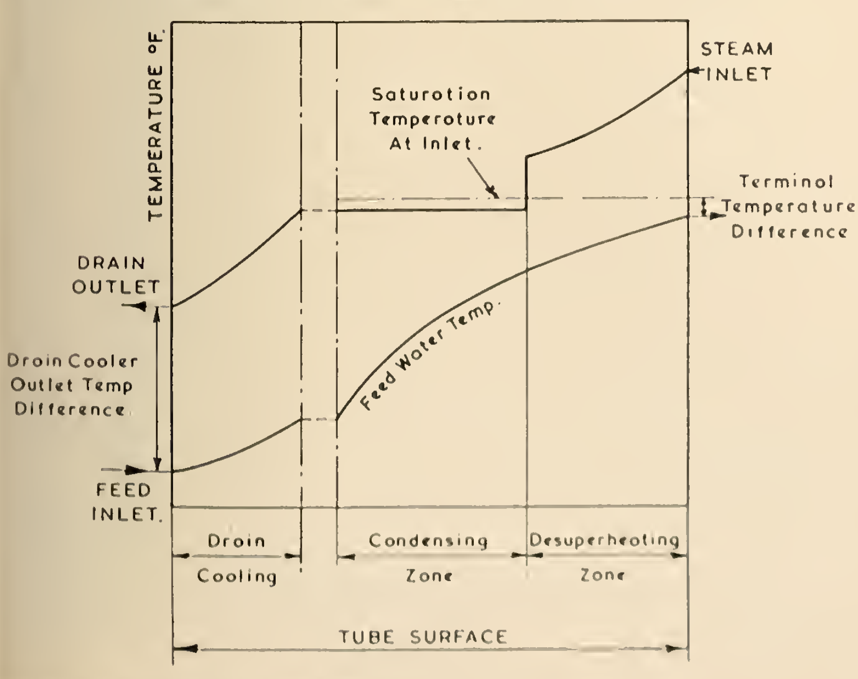


Fig. 9. Sectionalized view of combined low-pressure feed heater and drain flash condenser.

Fig. 10. Temperature diagram for desuperheating-type feed heater.



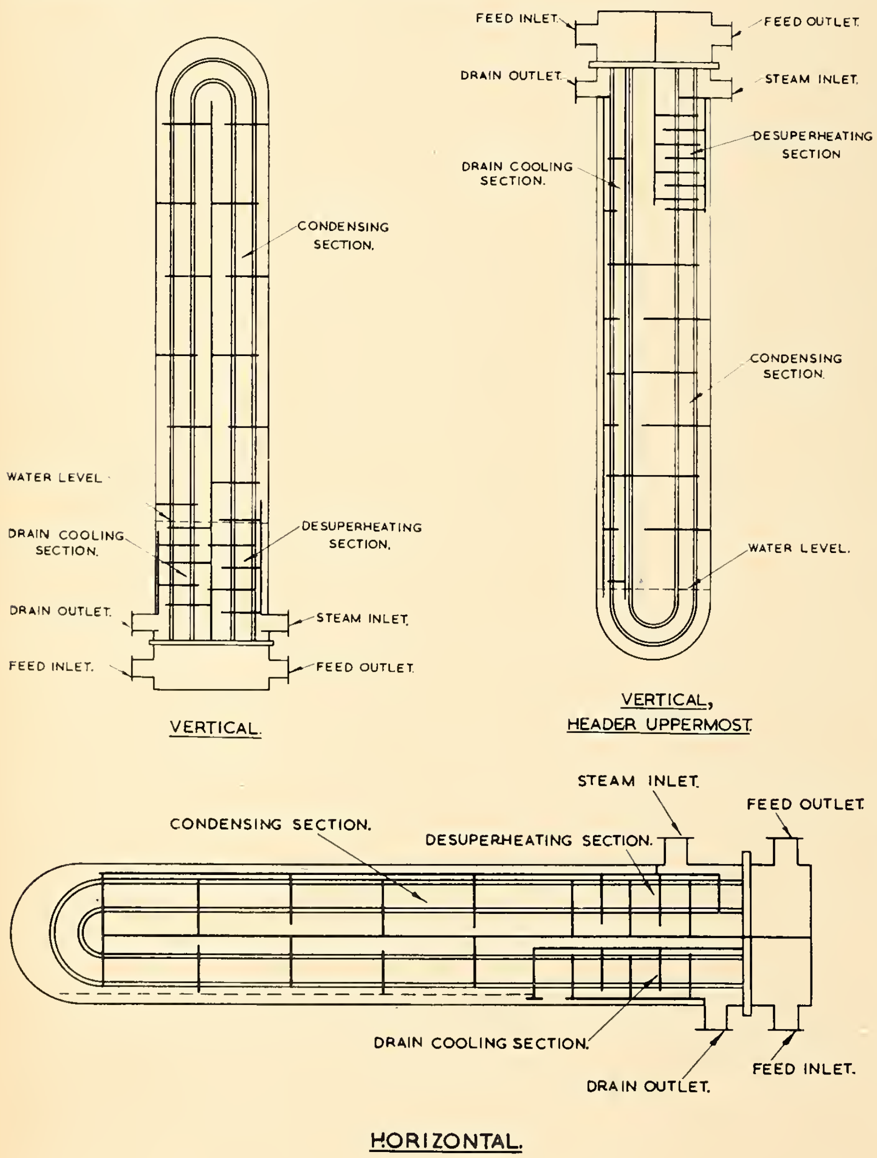
baffled accordingly. In the desuperheating portion of the nest the heat-transfer mechanism will be the same as that for cooling a non-condensable gas. The heat-transfer coefficients used can be based on a number of sources (e.g. 2, 3, 4). Thus for heat-transfer considerations the two portions of the nest, the desuperheating and the condensing, can be treated separately.

To enable surfaces to be fixed, it is also necessary to consider the pattern of temperature difference involved. Fig. 10 is a simplified conventional heat-exchange temperature diagram representing the conditions in a desuperheating heater. To the left of the diagram is a portion showing the temperatures in a drain cooler associated with the heater. The provision of drain-cooling surface will have been determined by the initial consideration of the economics of the feed-heating cycle, and such surface may be included in the feed heater proper, or in a separate vessel. Considerations affecting this choice will be discussed later.

The provision of the desuperheating zone, in which there is effective heat transfer from the superheated steam, is necessary when it is desired to obtain a terminal temperature difference of less than approximately 2°F. It is also possible (depending on the degree of superheat) to provide a feed outlet temperature above the saturated steam temperature. This is usually called a 'negative terminal temperature difference'.

Economic consideration of a particular heater can also justify the use of a desuperheating zone when a terminal temperature difference of more than 2°F is required. Such consideration will be dependent on the amount of super-heat in the bled steam and the feed-water temperature rise through the heater.

Fig. 11. Representative methods of arranging desuperheating, condensing and drain cooling sections in high-pressure feed heaters.



A desuperheating zone should have baffling arranged so that the superheated steam flows in baffled cross-flow generally counter-current to the flow of feed water in the tubes.

Experience indicates that it is desirable to design on the basis that only some 70 to 80% of the superheat is transferred in the desuperheating zone but, as far as the author is aware, research work to substantiate both this and other aspects of heat transfer with superheated steam, is uncompleted at least in Britain.

In Fig. 10 the difference between the solid horizontal steam temperature line and the dotted line is shown to represent depression of the saturated steam temperature caused by pressure drop of the steam through the nest. This cannot be neglected, particularly since the terminal difference at the end of the condensing zone may be small.

After the steam has lost its latent heat in the condensing zone the condensate then enters the drain cooler for sub-cooling to the desired amount.

As stated above, the drain cooler may be in the form of a separate heater, or may be a special drain-cooling section incorporated in the main heater nest.

The disadvantages of the former are the extra space involved and the cost of what is virtually an extra heater, particularly as it involves an extra header.

The disadvantages of the integral drain-cooling zone are that it increases the complexity of the heater baffling, and also brings with it the possibility of reheat of the condensate in the drain-cooling zone by means of heat flow from other portions of the heater at higher temperatures. This factor places certain limitations on the design of integral drain-cooling sections, which have been considered in detail by Gardner (5).

General Construction Considerations

From the foregoing it will be appreciated that the nest of a high-pressure feed heater may have to contain on the steam side, two, or possibly three, distinct sections, with separate functions, which have to be arranged in appropriate juxtaposition to the feed flow in the tubes. There are various methods by which this can be achieved but Fig. 11 shows the elements of several, both for the horizontal heater, and those installed both with headers uppermost and inverted.

Consideration must also be given in heater design to the effect of

high-temperature bled steam on the components, particularly if the steam is introduced to one side only of the heater. Fig. 12 shows the nest layout of a heater designed to deal with this circumstance. The central inlet disperses the hot steam equally round the nest, and also ensures that it is desuperheated before coming into contact with the shell. The arrangement of tubes, to permit this central inlet, is radial, as can be seen from Figs. 12 and 13.

The number and size of feedwater heaters associated with large turbine-generators demands that their configuration shall be relatively flexible to enable them to be fitted in neatly with the general plant arrangement.

Horizontal heaters were often used on early designs, but later vertical heaters with headers at the top became standard British practice. On large machines, however, this brought in its train certain disadvantages of feed-pipe layout, and also problems, in larger sizes of heater, in lifting the heavy nest from the shell and in threading it back on replacement.

Current practice recognizes the advantages of the vertical heater with its header at the bottom. Feed-pipe arrangement is usually eased and the nest can be exposed by removal of the relatively light shell, which may be in several sections to reduce crane height. Header design can also be arranged so that both the header cover plate and the nest can be removed without breaking the high-pressure feed-pipe connections to the header.

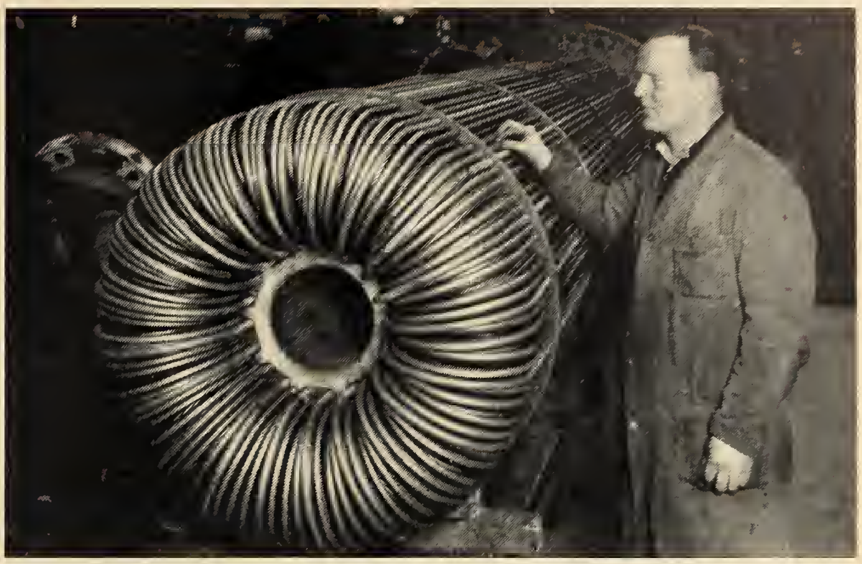


Fig. 13. End view of radial-pitch feed heater nest.

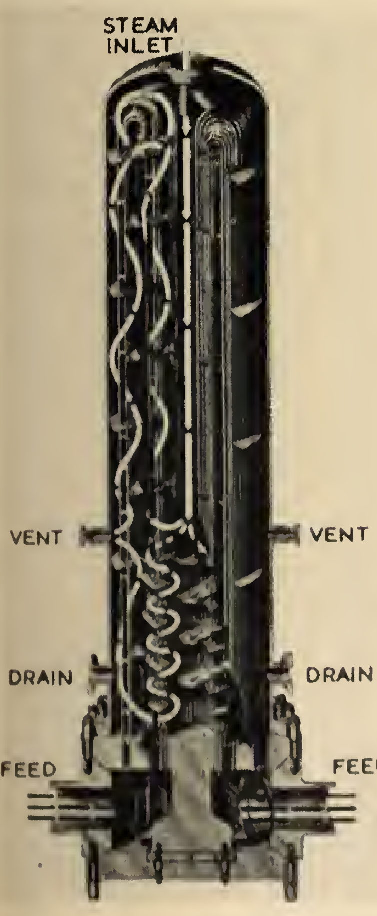


Fig. 12. Sectionalized view of radial-pitch feed heater.

It will be appreciated that in the largest units there is, with present methods and materials, an economic and practical limit to the size of single heater that can be built. Many modern plants are therefore designed with two (or more) lines of high-pressure feed heaters in parallel, to reduce the size of the individual heater. This trend, accepted for practical reasons, has certain advantages, for example, more flexible operation with a saving in valves and pipework, on main feed lines and drains.

Tube Materials and Stresses

For many years it has been the practice to fit brass tubes (usually 70/30 alloy in Britain) to low-pressure heaters, air ejectors, low-pressure drain coolers, etc., and this class of material is still adequate for current feed-cycle conditions.

Initial experience is now also being gained with aluminum tubes in L.P. heaters and ejectors.

At one time phosphorous deoxidized copper tubes were used in high-pressure feed heaters up to metal temperatures of 300°F.

As feed pressures and temperatures increase, the maximum allowable tube-wall stress in copper tubes is reached and it becomes necessary to use an alternative material, commonly one of the copper-nickel alloys.

Fig. 14 shows the allowable tube-wall stresses with wall temperature, for the materials in more general use, and Fig. 15 illustrates the limiting feed pressures with particular sizes of tube. It will be noted that the calculation of tube-wall stress by either the well-known Lamé formula, or the A.S.M.E. Code method, gives virtually the same result. Other references regarding stresses in cylinders are given in the bibliography.

The 70/30 and 90/10 cupro-nickel alloys have been widely used as high-pressure feed-heater tube material, but recent experience has shown that, in certain circumstances, tubes of 70/30 cupro-nickel exhibit a propensity to heavy scaling and gradual weakening. The evidence so far available indicates that scaling is closely linked with the number of times a turbine-generator unit has been started and virtually every case of scaling has occurred after periods of double-shifting. Experience suggests that such scaling does not occur with 90/10 cupro-nickel alloy, and therefore it seems reasonable to assume that scaling is in some way linked with the nickel content of the tubes. The advent of this trouble, together with the fact that present and projected cycle conditions are beginning to approach the limit of practical application of 70/30 or 90/10 cupro-nickel, has emphasized the necessity for considering alternative tube materials.

As can be seen from Fig. 14 Monel metal could be considered as an alternative material, but is a very costly alternative, with the result that ferrous tubes, in stainless steel for special applications, or in low-alloy steels or mild steel of superheater tube quality can become attractive. In this connection the effect of the conductivity of the tube material

on heater size has to be borne in mind, and approximations to the comparative influence of tube material and wall thickness are shown in Table 1. Besides the conductivity of the metal itself, oxide and dirt film of varying natures also have their influence on the heat transmission surface required.

When considering tube sizes in high-pressure heaters, certain advantages are to be derived from keeping the tube diameters down to the practical minimum of say ⅝ in. with 16 or 14 S.W.G. walls. This results in an easing of header and tube-plate design problems due to the smaller diameter of heater. In spite of the fact that the smaller tube results, for a given duty, in a relatively larger number of tubes and tube-end joints, this in itself is not significant if a satisfactory tube-plate joint is evolved.

Aspects of Header Construction

In the construction of heater headers, particularly those for high pressures, there are two factors of paramount importance.

(a) The tube to tubeplate joint.

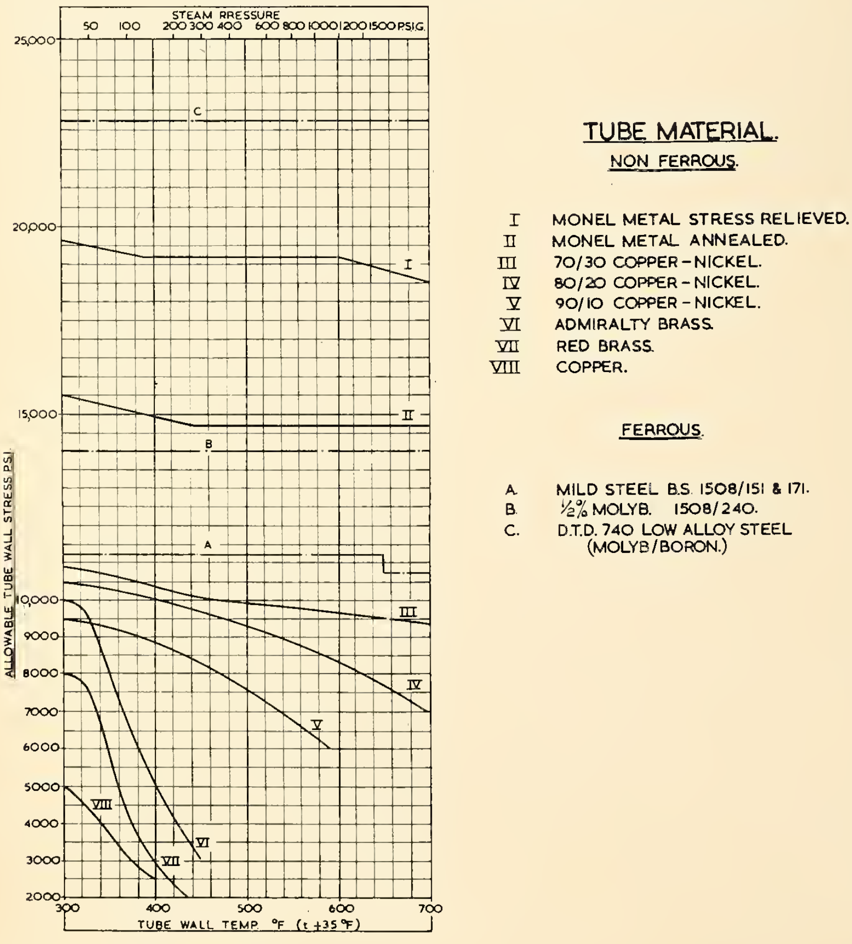
(b) The design of the header and its closure.

THERMAL CONDUCTIVITY OF TUBE MATERIALS FOR FEED-HEATERS AND HEAT-TRANSFER FACTORS FOR MATERIALS AND WALL THICKNESS TO BE APPLIED TO BASIC HEAT-TRANSFER VALUES

Material	*Composition, nominal, percent*	*Thermal conductivity of metal, B.t.u. per ft.²/in./H/°F*	*Suggested reduction in overall heat transfer K for material and tube-wall thickness (⅝ in. to 1 in. o.d. tubes)*			
			18 SWG	*16 SWG*	*14 SWG*	*12 SWG*
Arsenical copper	0.35 arsenic	1190	1.00	1.00	1.00	0.95
Admiralty mixture	70 copper, 28 zinc, 1.7 tin	768	1.00	1.00	0.96	0.90
Aluminum brass	2 aluminum	696	1.00	1.00	0.96	0.90
Aluminum bronze	5 aluminum	552	1.00	1.00	0.95	0.88
Carbon steel	0.06 carbon, 0.18	340	1.00	0.99	0.93	0.85
Low-alloy steel	2¼ chromium, 1 molybdenum	325	1.00	0.98	0.92	0.84
Copper-nickel	90/10	264	0.97	0.91	0.85	0.77
Copper-nickel	80/20	252	0.95	0.88	0.82	0.73
Copper-nickel	70/30	204	0.92	0.84	0.77	0.68
Monel	67 nickel, 30 copper	180	0.89	0.82	0.75	0.65
Stainless steel	16–18 chromium, 11–14 nickel	120	0.84	0.78	0.70	0.58

There are basically two means of effecting the tube to tubeplate joint, firstly by expanding, or secondly by some form of welding process.

Fig. 14. Curves of maximum allowable tube-wall stress for usual materials.



The Tube-Expanding Process

The conventional method of making tube-to-tubeplate joints has for many years been the well-known roller expanding process. During this process the tube, and to a certain extent the tubeplate metal, are deformed permanently, and the strength and permanence of the joint is determined by the pressures set up between the two contacting surfaces, and the friction between them. Fig. 16 depicts the three basic phases of tube expanding: (a) assembly of tube to tubeplate: (b) tube contacting hole surface: (c) completion of expanding of joint.

Experience indicates that the contact pressure between the two surfaces and consequently the joint strength increase with the amount of expanding done on the joint only up to a distinct maximum. Further work done on the joint reduces its strength because it can lower the elasticity of the materials of the joint.

Since expanded joints rely partly on friction for their strength, the holding strength could be supposed to increase as the roughness of the contacting surfaces increases (within reasonable limits) but the holding strength alone is not the only requirement of a good joint.

The joint must also be tight or leak-proof, and experience has shown that a tight joint for the high-pressure heaters can most satisfactorily be made with smooth contacting surfaces. Whilst the holding strength of the smooth joint may be lower than one with rough surfaces, it has been

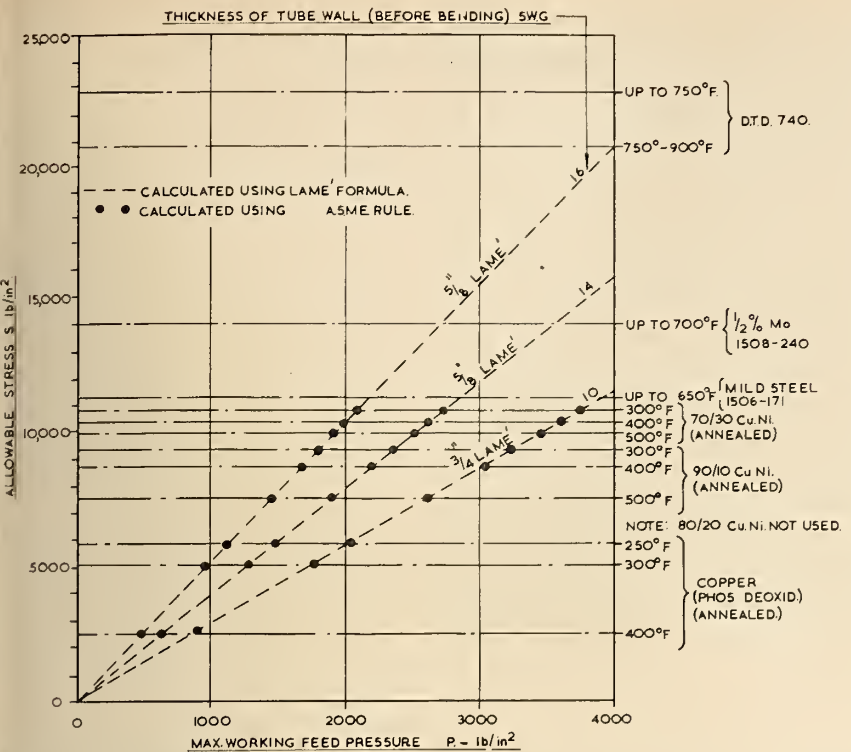


Fig. 15. Limiting feed pressures in feed heater tubes with particular sizes of tube and material.

proved to have sufficient strength in the materials and tube sizes common in high-pressure heaters. Consequently the smooth joint has been used, as in the author's experience the real problem is not that of producing a joint with sufficient holding strength, but one that is sufficiently leak-proof. If additional holding strength is required, then the additional friction or shear strength can be inserted under controlled conditions by the machining of one or two exact grooves in the smooth bore of the hole.

The problem of making a satisfactory joint has on low-pressure plant been comparatively simple because of the low pressure involved, but on high-pressure heaters with working feed pressure of 2,000 p.s.i.g. and over, much thought has been devoted to development of a satisfactory joint to be as leak-proof as possible. In high-pressure heaters through which feed water is passed at full feed pump pressure, it has in the author's experience always been found that where leakage occurs through expanded joints between non-ferrous tubes and steel tubeplates that the outer surface of the tube within the joint is little affected, but the steel tubeplate-wall surface becomes eroded to an extent dependent upon the time for which the leakage is allowed to proceed.

It was at first thought that leakage between the tube and tubeplate arose owing to imperfections in the finish of the closely limited bores of the tube-plate holes only, and considerable effort was therefore directed toward producing unblemished-finish holes of high dimensional accuracy. Fig. 17 shows the number of tools, and consequently the operations necessary to achieve this result. Fig. 18 shows the tool room conditions under which it is necessary to produce heater tubeplates to achieve the necessary quality of product. Further evidence, however, indicated quite clearly that it was not only the finish of the tube wall that was important but also the finish of the tube end to be expanded into the tubeplate. Typical evidence leading to this conclusion is shown in Fig. 19, showing how the draw mark on the tube end coincides with the eroded portion of the tubeplate. This conclusion was based on a body of evidence consisting of failed tubes, carefully drawn out from the tube holes by means of a specially developed drawing device shown in Fig. 20, when it was found that the tube end surfaces had draw marks or handling scratches longitudinally and spirally, through which defects it became obvious that the leakage was initiated. Furthermore, as a result of this evidence, severe doubt exists as to whether the roller expanding process materially closes these marks and therefore they still remain as a potential weakness at the joint. This has meant that, as well as producing as near-perfect a tubeplate hole as possible, it is also necessary to examine very carefully all tube ends during assembly, so that draw marks or scratches can be polished out, or the tube rejected where these marks are too deep for satisfactory treatment.

Control of Expanding

There are two main methods by which the desired amount of expanding may be attained and continued:

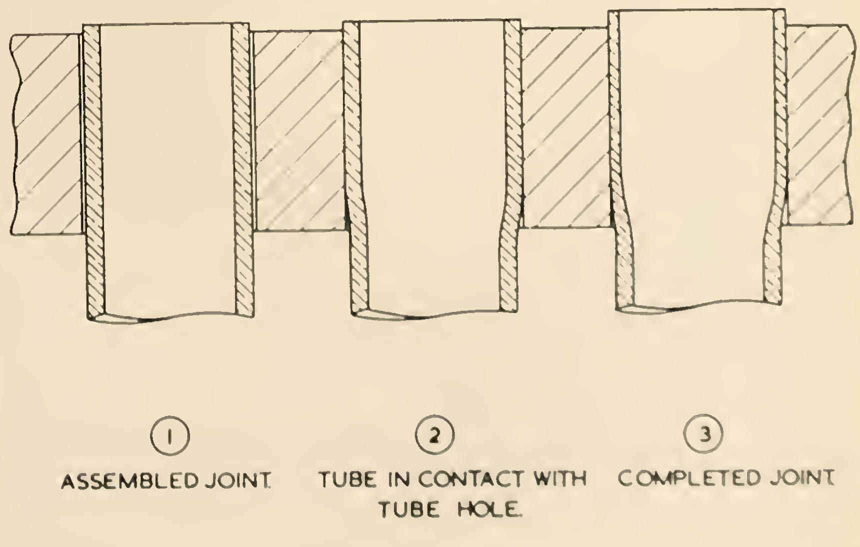
1. Based on measurement of the change in tube dimensions brought about by the expanding process.

2. Based on measurement of the actual power input to the expander to produce a desired effect.

Dimensional Changes

Much work has been done by various workers on this subject and it is only possible here to give the general consensus of opinion. For non-ferrous tubes in feed heaters, the op-

Fig. 16. Three phases of tube-expanding process.



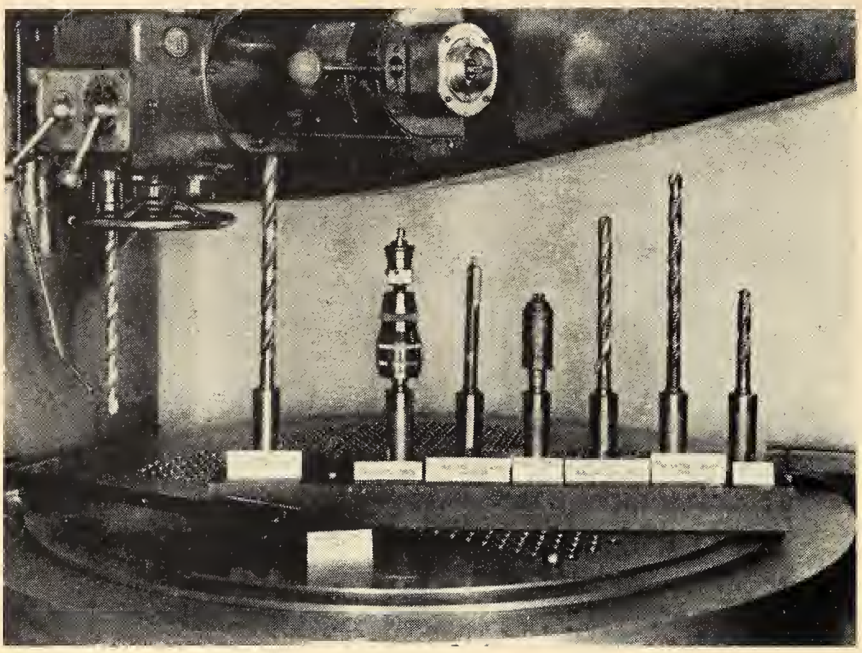


Fig. 17. Sequence of tools required for production of mirror-finish holes in high-pressure feed heater tube plates.

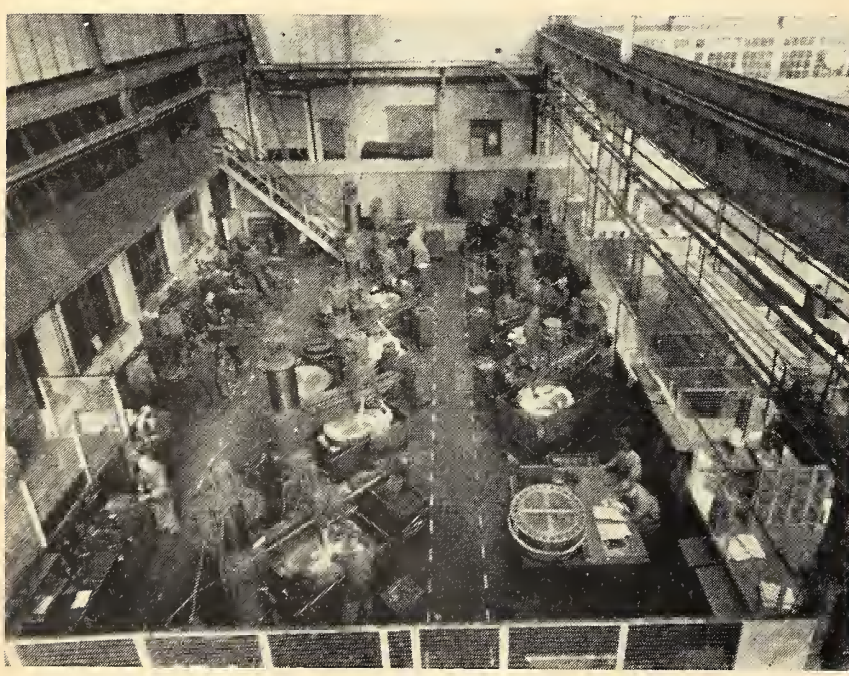
timum result would seem to be achieved by expanding the tubes so as to reduce the wall thickness by approximately 5%.

Use is also made frequently in boiler work, particularly in Europe, of "Tube End Expansion" figures, and here, as a general guide, growth at the tube end, axially, should not exceed about 1 to 1.2% of the tube-hole diameter.

Torque-Controlled Tube Expanding

In hand expanding, the amount of torque is determined by the skill and experience of the operator, who relies on the 'feel' of the process. While this conventional method can achieve first-class results, the use of a hand ratchet or carpenter's brace to drive the roller expanders has one major disadvantage when used over a large number of tube ends, which is that the degree of tightness of the expansion may vary as the operator becomes tired or distracted. The need for some form of adjustable power-driven expander to ensure consistency of tightness has long been recognized, and development of several forms of torque-controlled drives for expanders was commenced many years ago.

Fig. 18. View of tube-plate drilling shop.



Developments led to the use of a standard two-speed electric drill of ⅝ in. nominal capacity supplied through an electrical control box. This control box incorporates a variable current cut-out and a short-delay device together with a reversing switch. The sequence of operation of the control device is as follows:

The particular value of current appropriate to the torque required for the material and size of tube being expanded, is set by means of a movable pointer on the sensitive ammeter, and the drill switch is closed. The drill then drives the expander tool until the level of torque desired, and consequently the desired current, is reached, at which point the current cut-out operates and stops the drill motor.

The delay device then operates and, after a short period, reverses the motor so that the expander can be withdrawn without further switching action from the operator other than the initial closing of the drill

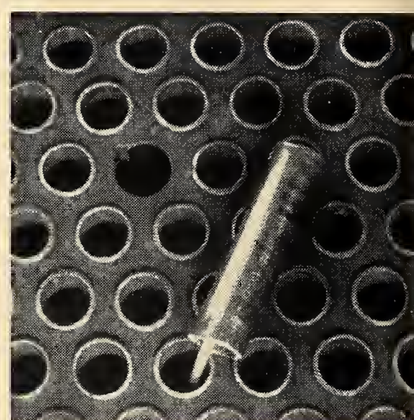


Fig. 19. Withdrawn specimen of feed heater tube showing score mark in tube end corresponding to erosion defect in the tube plate.

switch. This has proved a satisfactory and reliable tool for use with ferrous and non-ferrous tubes up to 1 in. outside diameter as normally used in condensers and heaters and has been in regular use for the last few years. It has been deliberately kept as simple as possible in construction. The control box is checked for calibration purposes by comparing the expanded tube pull-out with a particular ammeter setting with the desired standard values arrived at on the basis of pull-out tests. A photograph of the equipment is shown in Fig. 21 and in use by an operator in Fig. 22.

Soundness of Expanded Joints

In expanding the ends of several hundred tubes in a feed heater, the possibility arises that the odd few tube ends have not been fully tightened due to such causes as unnoticed

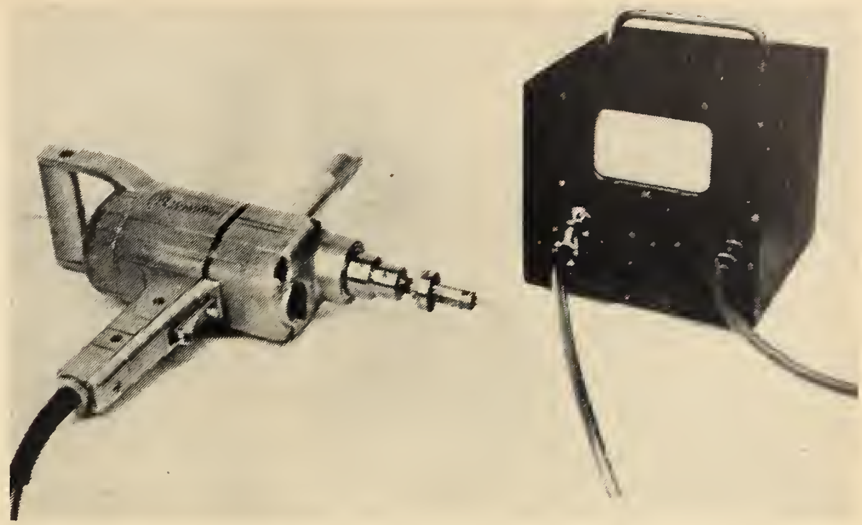
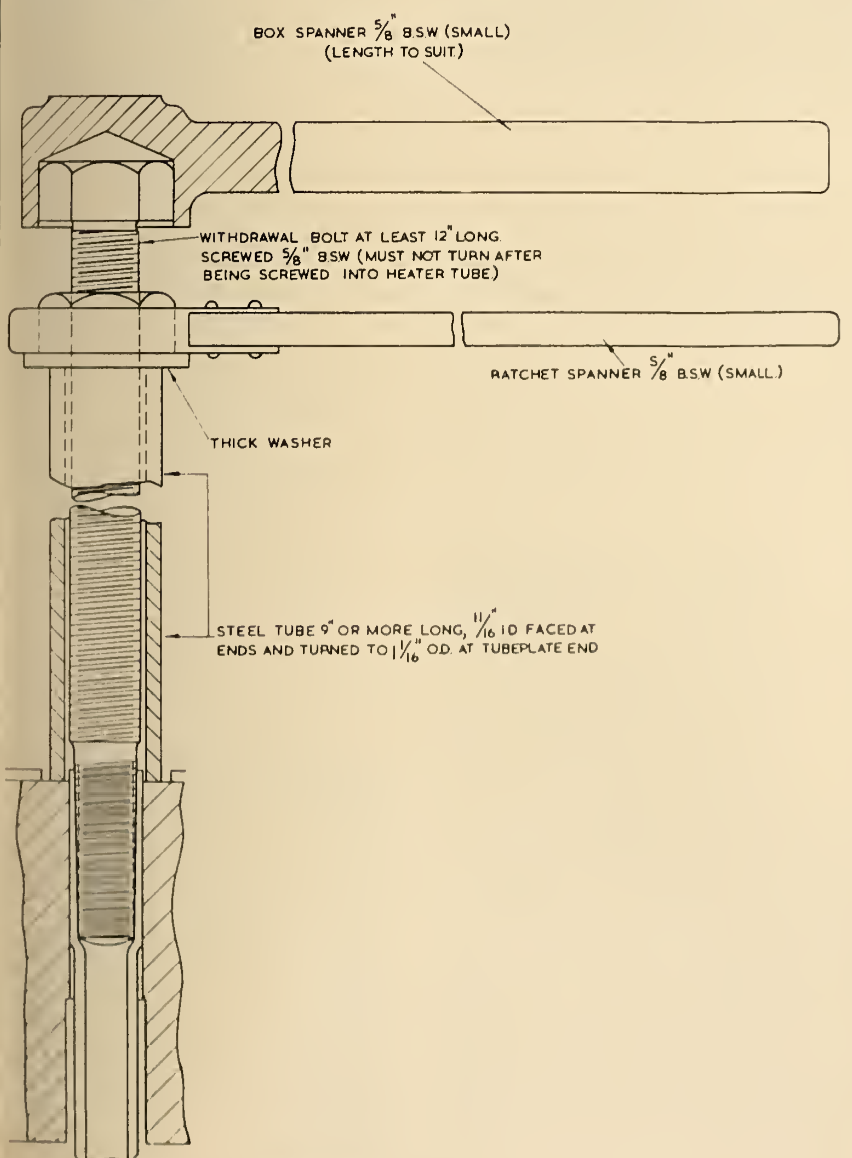


Fig. 21. Automatic tube-expanding tool.

vear of the expander, maladjustment f the torque-controlled tool, tiring or istraction of the operator, material aults in the odd tube, etc. The need as, therefore, apparent for some form f inspection which could be applied) the tube end to check sound exansion prior to the complete assemly of the header and nest for the onventional hydraulic test, in order o obviate the considerable amount f dismantling work incurred should he hydraulic test reveal defective exansions.

Development of an ultrasonic ube-tightness comparator was thereore put in hand. The basic principles f the instrument are similar to those sed for ultrasonic detection of maerial flaws such as laminations in steel late. Although investigations are still n an early stage, and the developnent of both the method and a tool uitable for workshop use is not yet omplete, laboratory work shows that it is possible to obtain sufficiently discriminating comparative joint-tightness indications which can be displayed on an oscilloscope. Two quartz crystal probes (one transmitter and one receiver), of which the transmitter generates ultrasonic waves by piezo electric effect, are inserted in the adjacent tubes and differences in joint tightness are apparent from the form of traces on the associated oscilloscope screen. The trace from an obviously tight pair of tubes is selected as a criterion and the remainder are progressively compared with this, thus revealing any tubes where the expanding operation has been inadequate. Fig. 23 shows the nature of typical results.

ig. 20. Special tool for withdrawal of feed heater tubes with minimum damage o tube end surface.



Tube Pull-Out Tests

To preset the torque-controlled tube-expanding device, it was necessary to carry out a long series of pull-out tests to determine the correct degree of tube-rolling tightness to suit the various types of low-pressure and high-pressure equipment. In conjunction with each test it is of course necessary to consider the relative amounts of thinning of the tube walls which take place during the expanding process.

Effect of Heating and Cooling Cycles on Tightness of Roller-Expanded Tube Joints

To ascertain the effect of heating and cooling in operation on the holding power of roller-expanded tube joints in high-pressure heaters, a large number of pull-out trials were made on test pieces consisting of heavy steel bushes, into which short lengths of tube in copper-nickel, and, alternatively, copper, were roller-expanded by the normal technique.

Some test pieces were pulled as made, but the majority were heated to various steady temperatures up to 800°F for one hour, and afterwards

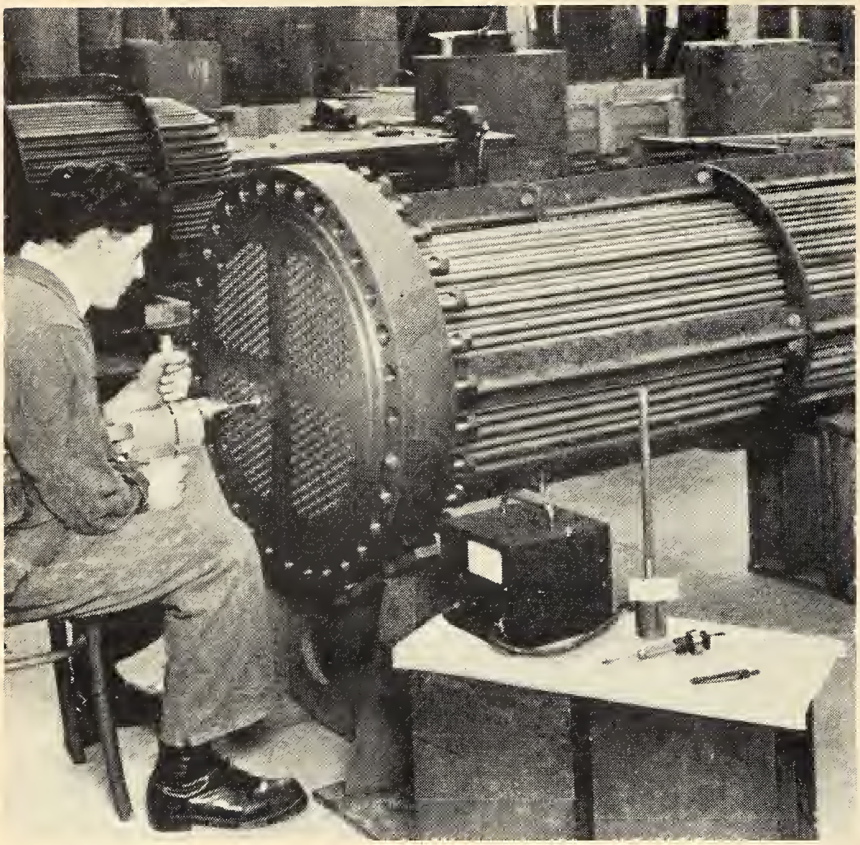
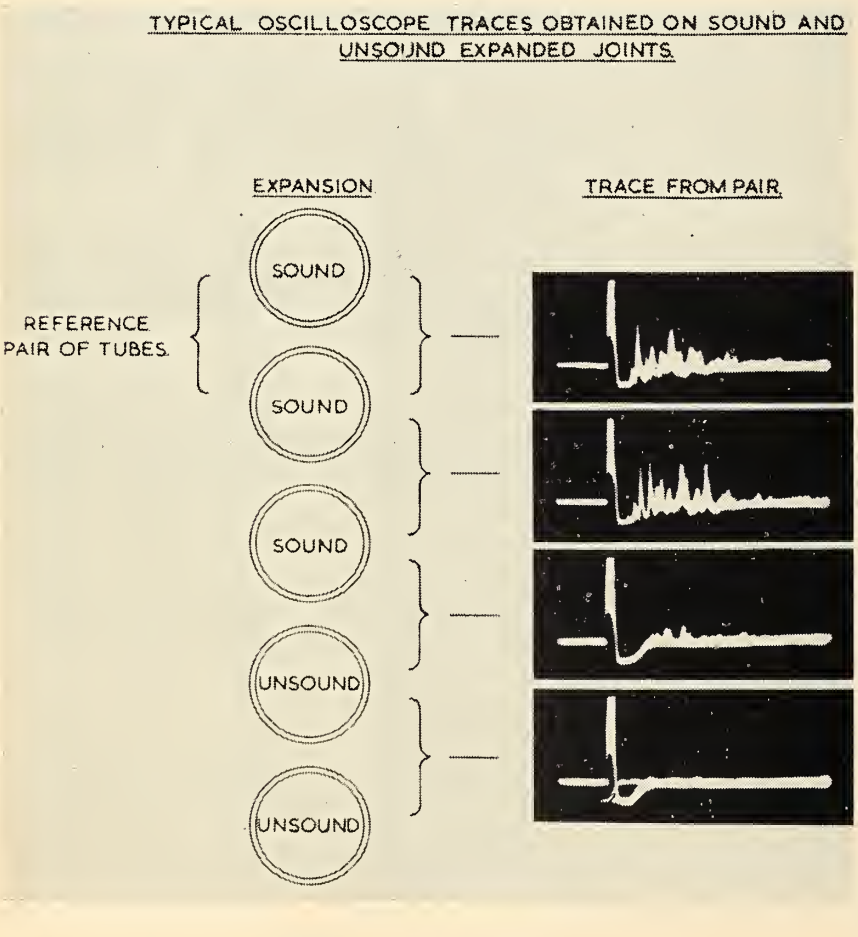


Fig. 22. Automatic tube-expanding tool in use.

Fig. 23. Typical oscilloscope traces obtained on expanded joint comparison.



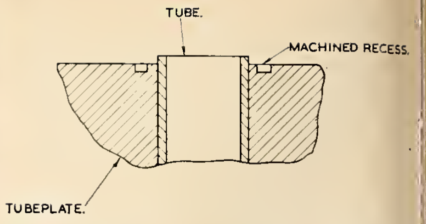


Fig. 24. Spigot-type tube plate preparation prior to welding.

cooled in air, before pulling out the tubes in a tensile testing machine.

From the results of these tests the following typical information was derived:

(a) Copper Tubes

From the maximum pull-out load of little over 4,000 lb. with ⅝ in. o.d. 14 S.W.G. tubes, there was a marked reduction in holding power on specimens heated above 300°F (corresponding to 67 p.s.i.a., steam) thus imposing a severe limitation on the use of copper tubes with roller expanded ends in high pressure heaters, since the allowable tube wall stress of this material also falls rapidly over 300°F.

(b) 70/30 Cupro-Nickel Tubes

From a maximum pull-out load of some 5,700 lb. with ⅝ in. o.d. 16 S.W.G. tubes, there was a marked reduction in holding power over 600°F (corresponding to 543 p.s.i.a. steam.).

In normal operation, it is likely that the temperature of the tube walls at any part of the ends of the tubes does not exceed the saturated temperature of the heating steam except where the heater is so designed to take advantage of a material amount of superheat, in which case the wall temperature is likely not to exceed about 35°F above the saturated steam temperature.

The effect of tubeplate hole sizes relative to the tube diameter was also investigated, the holding power reducing rapidly with unnecessary increase in hole size. For the tube sizes used it has been found desirable to have a tolerance on tubehole diameter 0.625 in. + 0.002 in. to + 0.008 in. for high-pressure heaters.

Numerous similar cold tests have been made with brass and other alloy tubes as used for low-pressure heaters (and condensers) but in these cases both the tube load and the water pressures are so much lower that pull-out loads of about 2000 lb. in steel plates or about 1500 lb. in brass plates can be satisfactory.

Velding of Tube to Tubeplate Joint

There are two basic methods by vhich this can be achieved:

(a) By welding the tube to the ıbeplate on the "feed" face of the late.

(b) By welding the tube to a ub on the "steam" face of the plate.

In the first method of welding to he feed face of the tubeplate, sucess has been achieved with a number f material combinations.

Initially some success had been btained by resistance welding of lared ends of mild steel tubes of small).D. and wall thickness, but this was ot considered practical or adequate or ⅝ in. o.d. heavy gauge tubes.

The common features of the maority of subsequent work were the se of an argon arc welding process nd the spigot type of tubeplate preparation (Fig. 24).

Techniques have been evolved or the following material combinaions.

70/30 Cupro-Nickel to Nickel lated Mild Steel Tubeplate.

18/8 Stainless Steel to Mild Steel ubeplate.

Mild Steel Tube to Mild Steel ubeplate.

The use of nickel plating of the nild steel tubeplate when welding upro-nickel tubes was found to be of reat benefit both in increasing shear trength and the elimination of porsity. In this combination a monel netal filler wire is used.

The following illustrations demnstrate the nature of the welds.

Fig. 25(a) shows the cross secion of a typical weld.

Fig. 25(b) shows a cross section t high magnification, of a cuproickel to nickel plated mild steel weld, nd indicates the continuity of the ickel plating.

Figs. 26 and 27 show typical trial ieces for testing mechanical strength f welds.

Fig. 26. Cupro-nickel to mild-steel welds. Completed welds, on pressure test sample.

ig. 25a. Cross-section through typical eld of cupro-nickel tube to mild-steel ube plate.

On the test block shown, no failure of welds took place and the particular test was terminated, as can be seen, by a tube failure (at 12,500 p.s.i.). It will be noted that the free ends of the tubes are closed by plugs secured by a weld process similar to that on the tubeplate face.

Fig. 28 shows a portion of a tubeplate with a completed weld. It will be noted that with the spigot type of preparation and the use of the Argon Arc process, individual welds are achieved which can be dealt with separately for non-destructive testing, rectification etc. The particular example shown is a high pressure feed heater with stainless steel tubes welded to a mild steel tubeplate; the operating pressure is 2,700 p.s.i.g.

Fig. 25b. At higher magnification showing continuity of nickel plating.

The introduction into service of heaters with such welded tube joints has emphasized not only the necessity for the highest possible standards of manufacturing techniques, but also the most advanced methods of non-destructive testing to prove the soundness of each completed weld, and it is therefore necessary to supplement the conventional hydraulic test. One satisfactory additional method available at the moment is the well known system of halogen gas leak detection in which a halogen atmosphere at a pressure of approximately 10 p.s.i. is maintained on the shell side of the heater, and the tube side of all welds inspected by halogen leak detection apparatus (Fig. 29). Another and current development is the application of the technique of ultrasonic testing to all tube welds. So far the results are hopeful. Techniques such as the use of dye penetrant or magnetic crack detection have not proved satisfactory for this application.

After such complementary tests as are practical have been carried out, the assembly is still subjected to a final hydraulic test; this is continued for 72 hours, somewhat longer than the conventional testing time of welded vessels.

Certain designs of high-pressure heaters show a similarity to boiler superheater methods of construction

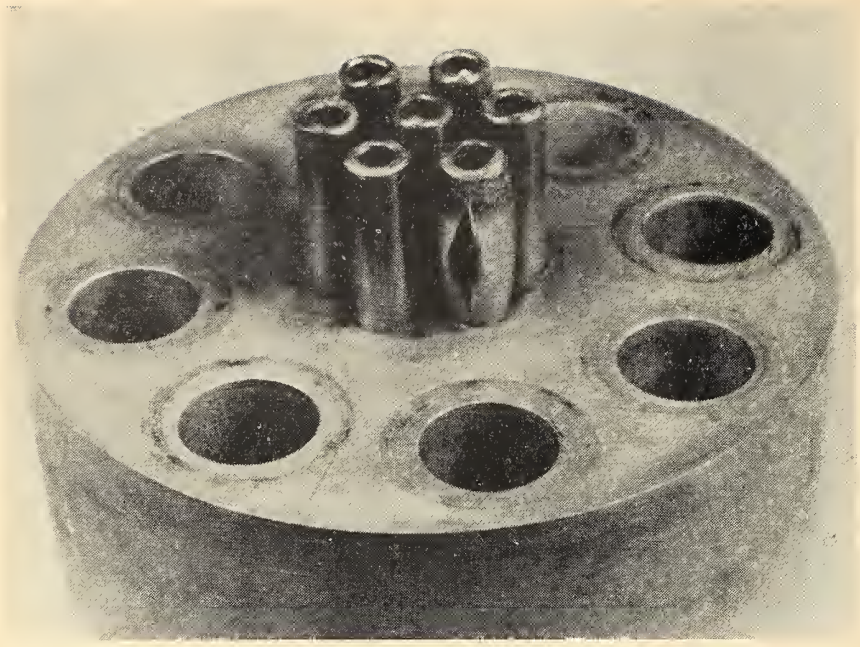


Fig. 27. Cupro-nickel to mild-steel welds. Failed pressure test sample, showing burst tube.

Here the tube is welded to the steam side of the tubeplate or header. Fig. 30e shows a typical method of construction. A stub piece often of forged construction is welded to the tubeplate. This stub may have a solid centre which is drilled away after welding thus removing the root run of the weld in the process, and eliminating a potential source of trouble. The tube proper is then welded to the projecting stub pipe. A further development in this field consists of an automatic welding tool which performs the weld between a short stub, machined on the face of the tubeplate, and the tube end, from inside the stub and tube bore, thus permitting close pitching of the tubes.

With the majority of such welds, on the steam face of the header, the actual weld cross section is generally much greater than that possible with the spigot type of preparation.

The Design of the Header and its Closure

The design of tubeplates is a subject on which an extensive literature exists and it is not possible in a paper of this nature to add to this body of information; however, linked with considerations of tubeplate design is the problem of designing the heater header as an entity.

This has in the author's opinion, three main facets,

1. The closure problem, by which is meant the provision of sufficient material in tension or shear to affix the header components one to another.

2. The "joint" problem which consists of providing a joint arrangement which will remain tight not only under steady operating or test conditions but also under sudden variations, particularly of temperature, which can be experienced in service.

3. The "access" problem, which consists of providing a design in which access to the internals of the header permit of it being built and of future repairs and maintenance being carried out.

It is not possible to view the three aspects entirely separately and a particular design produced with the object of solving one, may also solve or lessen the severity of the other.

A conventional simple bolted construction, in which the tubeplate, header body, and cover plate if used, are all bolted together, with the fasteners in tension, is satisfactory for low and medium pressures, but when high pressures together with large diameters are involved, it is subject to definite limitations.

Firstly, the hydrostatic load in the cover of a high-pressure heater may often be of such a magnitude that it is virtually impossible to provide sufficient bolting material on a given p.c.d. and various design devices have to be used to overcome this.

Secondly the maintenance of a joint between faces by means of bolting material under tension can become a matter of extreme difficulty. When variable temperature conditions occur, such as are encountered under load throw off, the body of the header can be chilled by cold feed, and the bolts still remain relatively warm. A slackening of the joint loading takes place. Under some circumstances it is virtually impossible to design a combined bolt and flange joint system with sufficient elasticity to compensate for the differential contraction which occurs.

Sketches showing the elements of some typical high-pressure headers are shown in Fig. 30.

Fig. 30a, shows a bottle type header in which the tubeplate and header body are combined in a single forging, with the neck of the body narrowed to reduce the load on the cover plate. A further version narrows the neck still further to permit the use of an elliptical closure of the boiler drum manhole type. While this

Fig. 28. Welding of tube ends as completed over a portion of feed heater tube plate.

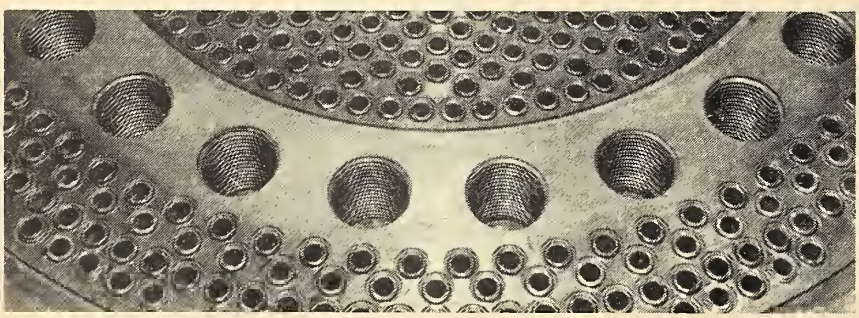
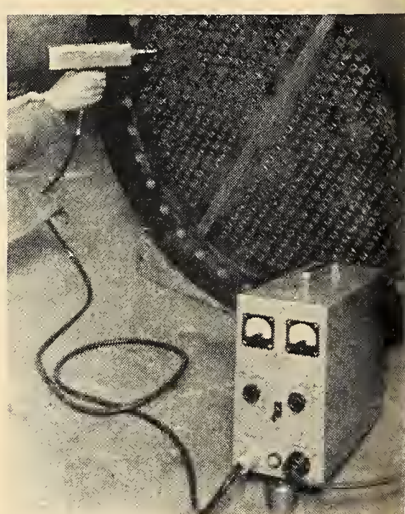


Fig. 29. Inspecting welds by halogen leak detection apparatus.



a relatively trouble free design it uffers from the disadvantages of high orging cost, and inaccessibility of the ube fixings both for initial construcon and future maintenance.

Fig. 30b, shows the principle of closure in which the cover plate to combined body-tubeplate forging is eld in place by a ring in shear. This rinciple of construction is widely sed, but there are many variants in ne detail method by which it is acomplished. The shear ring is in secons, and it is usual to include means f retaining these positively in posion, and forcing screws for removal c. A cover plate attached by this ethod will only carry the pressure ad, and the fluid-tight joint has to e made by some form of diaphragm losure underneath the cover, this diahragm being flexible and transferng the pressure load to the cover late and consequently the shear ngs. The junction between the outer dge of the circular diaphragm and ne body may be made with a clamped oint loaded by means of bolts, which e sometimes arranged to pass free through the cover plate, or by weldg the diaphragm to a suitable landg on the body. In this latter case ccess to the header internals necesstates the cutting away of this weld.

This type of closure has been sed, with many variations of detail esign, on feed heaters up to the ighest operating pressures yet built. has the advantage of reducing the umber of fluid-tight joints to one.

Fig. 30c, illustrates a type of esign made possible by the use of a adial-pitch tube-nest described earli in this paper. The tube plate has combined with it in one forging a centre post, mushroomed at its extremity.

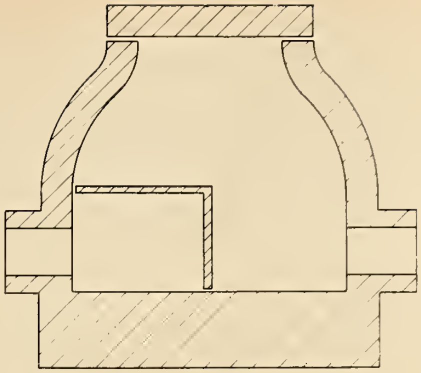


Fig. 30a. Bottle-type header.

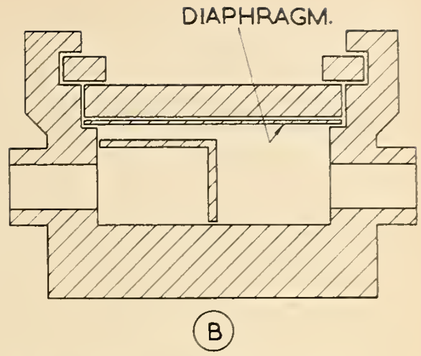


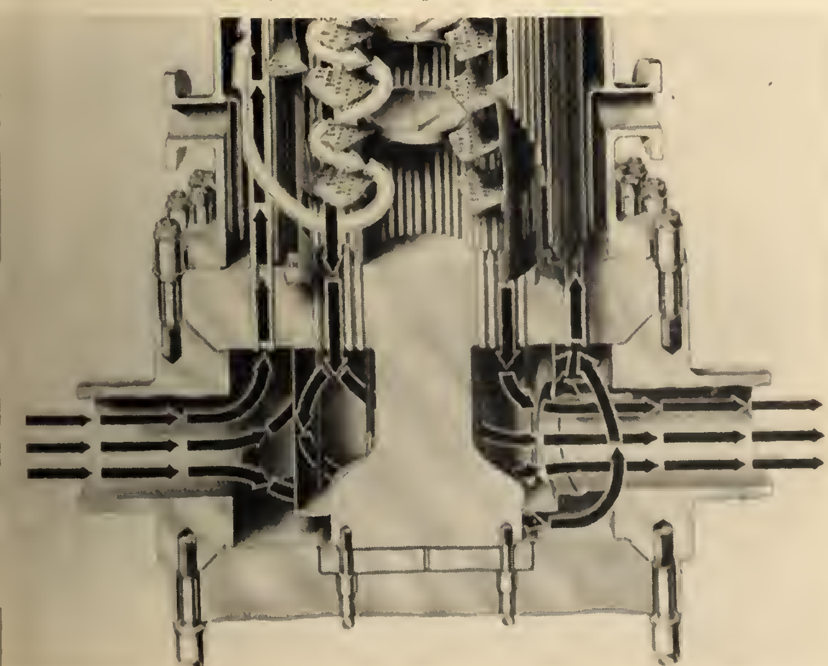
Fig. 30b. Ring-in-shear-type header.

The cover plate spans the whole area of the header but only carries the load on the toroidal area between the centre mushroom and the outer header barrel. The sealing diaphragm is clamped at its outer rim between the cover plate and the header barrel, and at its inner rim between the mushroom and a separate clamping plate bolted to the mushroom head, which is free to move relative to the cover plate. Any relative movement between the body and the centre post occasioned by temperature difference (i.e. between flows of the heater) can thus be accommodated.

A further variation of the 'ring in shear' type of closure is the breech block type of construction Fig. 30d, where by use of interrupted segments the shear sections can be made integral with the header body and the closure. While the closure carries the hydraulic load, the fluid tight joint has still to be made, either by diaphragm below the closure plate, or by deformable metal joint ring on the outer face, sealing the narrow annular gap between the closure and the header body.

A type of high-pressure heater often used in European construction, has a header and nest design derived from superheater methods of manufacture Fig. 30e. Here, the tubes, of either hairpin or double hairpin type, and of mild steel, are welded to a drum header in a precisely similar manner to that used for boiler or superheater construction. Stub tubes are first welded to the drums and the tubes proper then welded to the outer ends of the stubs. This type of construction has the advantage of virtually no joint problems, but access, either to the inside of the relatively small diameter header drum or externally to the tubes in the centre of the nest, for the purpose of maintenance in the case of leakage, is restricted.

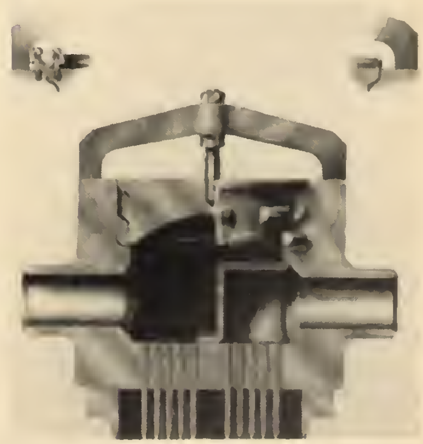
Fig. 30c. Radial-pitch tube nest.



Bolt Tightening

While current design trends tend to avoid the use of bolted construction for the highest pressure waterboxes such methods are still widely used in other circumstances, and can within certain limits be economical

Fig. 30d. Breech-block type header.

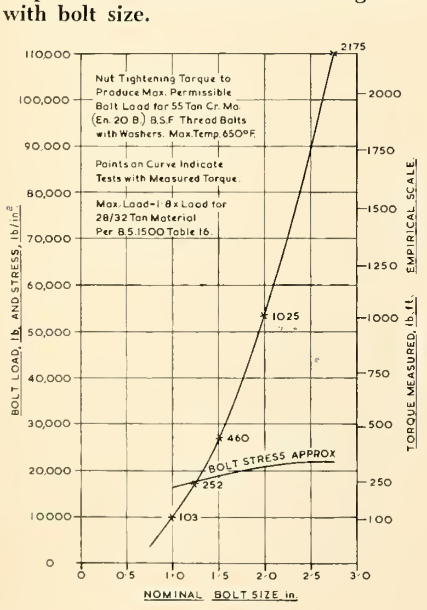


and satisfactory. It is now common practice on large bolts where tightening to a given consistent stress level is required, to use torque wrenches of one form or another and it is desirable to know the nut torque required to obtain such stress.

A number of investigations have been made of this matter, and the figures below refer to tests made with a torque wrench on a test rig mounted in a tensile testing machine which registered the load obtained. The nut face and threads were lubricated with molybdenum disulphide compound and a bronze (or in some cases steel) washer was fitted between the nut and the surface of the studded test piece. The bolt and nut material was 55-ton u.t.s. chromium-molybdenum steel (En. 20B) and the B.S.F. threads were a ground finish. Variations in the type of lubricant made little significant difference but absence of lubricant or of the washer considerably increased the torque required for a given load, so that the test figures are considered to give the minimum torque required. Some evidence is available that indicates that under usual commercial conditions the actual bolt load for a 2¾-in. B.S.F. bolt with an applied torque of about 600 lb. ft. is about 80% of the figure obtained on test of 30,000 lb.

From these tests it is possible to construct an empirical curve correlating the torque required to produce the maximum safe working load with a range of bolt sizes as in Fig. 31. The scale of torque required is based on the test conditions and would therefore produce under commercial conditions somewhat less than the bolt load indicated.

Fig. 31. Curve relating torque required to produce maximum safe working load with bolt size.



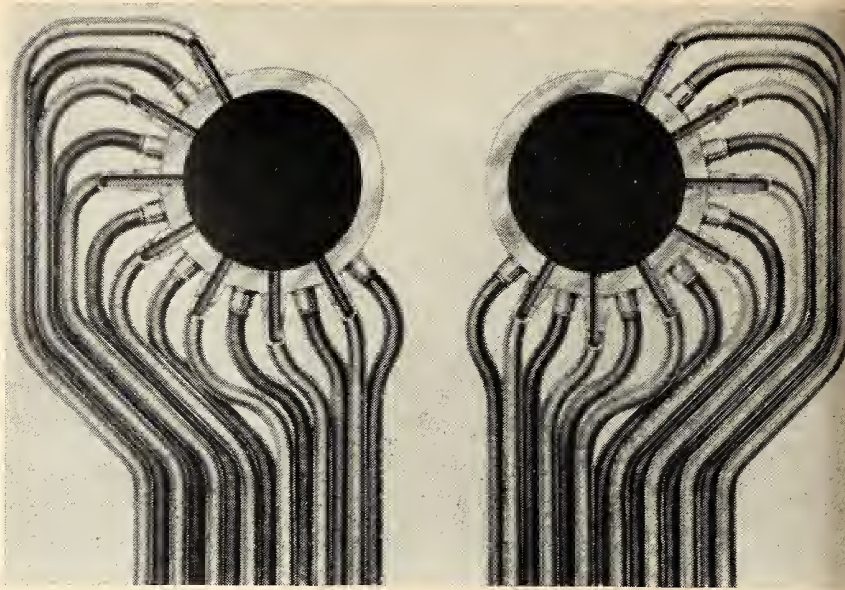


Fig. 30e. Drum header with stub tubes.

The Resilience of Compressed Asbestos Fibre Jointing

Compressed asbestos fibre (C.A.F.) jointing is made in a variety of thicknesses and forms, and information was required regarding its behaviour, particularly its resilience, under operating conditions. A number of tests of representative kinds of jointing, both reinforced and plain, were therefore made with a test rig which gave the compression of the joint and also provided for electrically heating the test joint faces, which were of mild steel.

The sequence of testing, devised to simulate, as nearly as possible, the practical case, was as follows:

1. Initial bolting up to about 1(ton/in.² loading. Relaxation of joint load under hydraulic test conditions
2. Loading again after comple tion of hydraulic test and holding loaded for 1 hour.
3. Loading to 15,000 lb. simu lating working condition (cold load ing). Heating while loaded to 450°F to represent feed-heater duty temper ature.
4. Loading 0-40,000 lb. whil hot to check resilience on short-tim test.

Fig. 32. Test curve from compression and heating trials on 1/32 in. thick wire reinforced C.A.F. jointing.

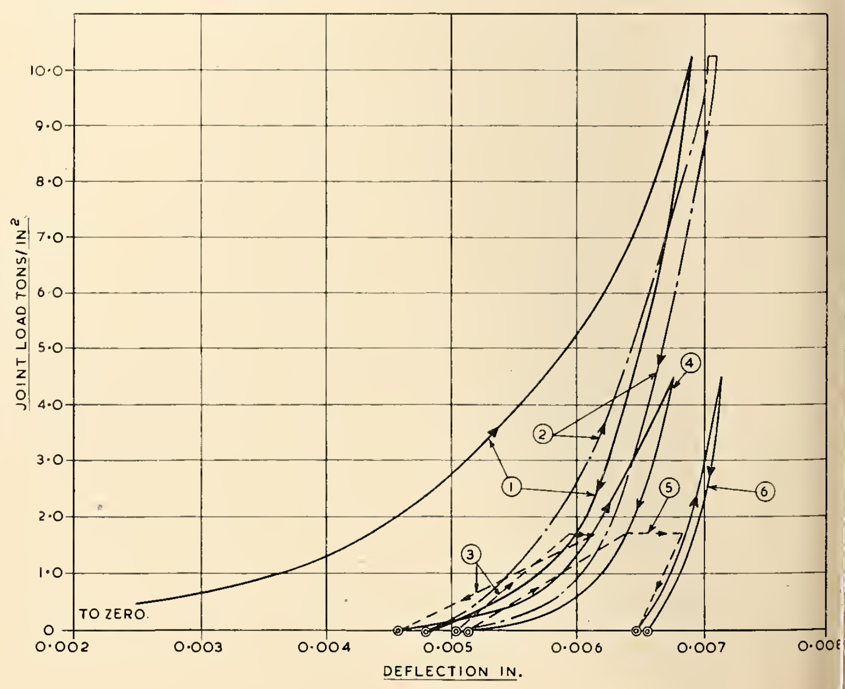


TABLE 2
TEST RESULTS FOR VARIOUS TYPES OF JOINT

ype of Jointing		*Thickness in.*	
'anufacturer A	*Nominal*	*Before Test*	*After Test*
.A.F..................	1/32	0.0340	0.0295
.A.F..................	1/16	0.0620	0.0540
.A.F. Brass-wire inforced............	1/16	0.0655	0.0540
.A.F. Steel-wire inforced............	1/32	0.0345	0.0305
.A.F. Double-woven eel-wire reinforced.....	1/32	0.0290	0.0220
'anufacturer B			
.A.F..................	1/32	0.0310	0.0260
.A.F..................	1/16	0.0615	0.0560
.A.F. Steel-wire inforced............	1/32	0.0330	0.0290

5. Loading to 15,000 lb. and olding for one hour to represent perating condition after having been eated and tightened up.

6. Loading to 0-40,000 lb. cold check cold resilience after service ondition.

Final thicknesses after the comlete cycle for various representative pes of joint are given in Table 2.

A sample diagram for the comete test on a 1/32 in. thick steelire-reinforced joint is shown in ig. 32.

Numbers adjacent to the various ortions of the curve correspond to e numbered sections of the test seience as given. The direction of the row head on the curve gives the ase of loading (up corresponds to crease, down to decrease) approiate to that part of the curve.

Because of the effect of heating the test apparatus, some doubt ay be expressed as to the relative splacement of curves 3, 4 and 5 uring the heat cycle, but the slope, rticularly of curve 6, is not in oubt. This shows the extremely small sidual resilience available once such joint has been heated under comession.

Measurement of the approximate ope of section 6 of the curves shows at the mean resilience over the nge of compression, 0 to 4½ ton/in.^{2} pproximately, is about 0.0001 in./n in.^{2}

Further information on the beviour of C.A.F. jointings under cold nditions has been published by onald and Salomon.[6]

onclusion

Current thinking on the steamrbine cycles in which feed heaters e incorporated leads to increasing mperature and pressure conditions der which the high-pressure heats particularly will have to operate. he supercritical cycle is already accepted and there is a trend to further increases in turbine unit size.

The necessity for the most reliable tube to tubeplate joint under such conditions, is in the author's opinion, leading to the more universal use of the welded joint, together with the development of more highly mechanized means for the manufacture of such joints of consistently high quality. With ever increasing feed pressure header design naturally tends to the monolithic, with as few openings and joints as possible, with the natural result of reduced access to the feed side of the tube to header joint. In such circumstances, particularly with ferrous materials, the welded joint on the steam side of the header may well become increasingly attractive.

Acknowledgements

The author wishes to express his thanks to Norman Elce, Director & Chief Mechanical Engineer of A.E.I. (Manchester) Limited, for permission to publish this paper. Grateful acknowledgement is also due to the author's many colleagues, in particular T. F. Thomas, whose work has made possible the availability of much of the information.

References

1. Baumann, K. 1949 Proc. Instn. mech. Engrs, Lond., vol. **160**, p.61, 'Heat Engines'.
   1920 Engineer, Lond., vol. **130**, pp.101, 127, 150, 'Feed Heating for Land Power Stations'.
2. McAdams, W. H. Kennel, W. E. and Addoms, J. N. 1950 Trans. Amer. Soc. mech. Engrs, vol **72**, p 421, 'Heat Transfer to Superheated Steam at High Pressure'.
3. Poensgen, R. 1961 Z. Ver dtsch Ing., vol **60**, pp.27, 47, 1917 Mitt. Forsch. vol **191-192**.
4. Widdell, T. 1951 Engrs Dig., vol **12**, June, 'Heat Transfer with Superheated Steam'.
5. Gardner, K. A 1957 Trans. Amer Soc mech. Engrs, vol **79**, p 1494, 'The Effect of Condensate Reheat on Mean Temperature Difference in Feedwater Heater Subcooling Zones'
6. Donald, M. B and Salomon, J M 1957 Proc. Instn mech Engrs, Lond, vol **171**, p.829, 'Behaviour of Compressed Asbestos Fibre Gaskets in Narrow Faced, Bolted Flanged Joints'.

Bibliography

CODES OF PRACTICE

Amer. Soc. mech. Engrs, Boiler Construction Code, Section VIII, Unfired Pressure Vessels.

British Standards Institution. British Standard Code 1500: 'Fusion Welded Pressure Vessels'.

Standards of Feed Water Heater Manufacturers Association Inc. (New York).

Tubular Exchanger Manufacturers Association, 'Design Code for Tubular Exchangers'.

TEXTBOOKS

'Heat Transmission'. McAdams, McGraw-Hill Book Co. 'Theory of Plates and Shells'. Timoshenko, McGraw-Hill Book Co.

PAPERS

Alexander, J. M. and Ford, H. 1957 Proc. Instn. mech. Engrs, Lond., vol. **171**, p.351 'Experimental Investigation of the Process of Expanding Boiler Tubes'.

Burnell, J. G. 1950 J. Instn. Engrs. Aust., vol. **22**, p. 229. 'The limits of Working Temperature for Copper Tubes Expanded Into a Steel Tubeplate'.

Dudley, F. E. 1954 Trans. Amer. Soc. mech. Engrs, vol. **76**, p.557, 'Electronic-Control Method for Precision Expanding of Tubes'.

Duncan, J. P. 1955 Proc. Instn. mech. Engrs, Lond., vol. **169**, p.789, 'The Structural Efficiency of Tube Plates for Heat Exchangers'.

Dunkley, W. H. 1947 Engineering, Lond., vol. **164**, p.592, 'Steam Condensers with Rolled-in Tubes'.

Fisher, F. F. and Brown, G. F. 1950 Amer. Soc. mech. Engrs, Paper No. 50-A-124, 'Expanded Tube Joints in Feed-water Heaters and Heat Exchangers'.

1954 Trans. Amer. Soc. mech. Engrs, vol. **76**, p.563, 'Tube Expanding and Related Subjects'.

Fisher, F. F. and Cope, E. T. 1943 Trans. Amer. Soc. mech. Engrs, vol. **65**, p.53, 'Automatic Uniform Rolling In of Small Tubes'.

Gardner, K. A. 1948 J. appl. Mech., Trans., Amer. Soc. mech. Engrs, vol. **70**, p.377, 'Heat Exchanger Tube Sheet Design'.

Goodier, J. N. and Schoessow, G. J. 1943 Trans. Amer. Soc. mech. Engrs, vol. **65**, p.489, 'The Holding Power and Hydraulic Tightness of Expanded Tube Joints'.

Grimison, E. D. and Lee, G. H. 1943 Trans. Amer. Soc. mech. Engrs, vol. **65**, pp.497-521, 'Experimental Investigations of Tube Expanding'.

Huff, H. A. and Kugler, A. N. 1954 Mech. Engng, vol. **76**, p.421, 'Welding Tubes to Tube Sheets'.

Lake, G. F. and Boyd, G. 1957 Proc. Instn. mech. Engrs, Lond., vol. **171**, p 843, 'Design of Bolted Flanged Joints of Pressure Vessels'.

London, J. C. 1952 Proc. Instn. mech. Engrs, Lond., vol. **1B**, p.259, 'Improvements in Thermal Efficiencies with Single Stage Reheating at High Steam Temperatures and Pressures'.

Maxwell, C. A. 1943 Trans. Amer. Soc. mech. Engrs, vol. **65**, pp.507, 521, 'Practical Aspects of Making Expanded Joints'.

Miller, K. A. G. 1952 Proc. (B) Instn. mech. Engrs, Lond., vol. **1B**, p.215, 'The Design of Tube Plates in Heat Exchangers'.

Nadal, A. 1943 Trans. Amer Soc mech Engrs, vol. **65**, p.865, 'Theory of the Expanding of Boiler and Condenser Tube Joints Through Rolling'.

Sachs, G. 1947 J appl Mech Trans Amer. Soc. mech Engrs, vol **69**, p A285, 'Notes on the Tightness of Expanded Tube Joints'.

Weir, J. G. 1929 Proc Instn mech Engrs Lond, vol **116**, p 5, 'Modern Feed-water Circuits'.

Wesstrom, D B and Bergh, S F 1951 Trans Amer Soc mech Engrs, vol **73**, p 553, 'Effect of Internal Pressure on Stresses and Strains in Bolted Flange Connections'

PAMPHLETS

1955 'The Strength of Copper Tubes and Cylinders' The Copper Development Association

EIC

UNIQUE DESIGN IN GLULAM

B. Madsen,
Chief Engineer, Glulam Products Limited, New Westminster, B.C.

Presented at the 75th E.I.C. Annual General Meeting, Vancouver, May 1961.

POTASH is one of the major components of modern-day fertilizers. Until recently potash had to be imported from New Mexico and transportation constituted a great part of the cost. It was, therefore, a find of great importance when deposits of potash were discovered in Esterhazy, Sask., and International Minerals and Chemical Corporation (Canada) Ltd., started plans for development of the rich mine. The potash is located 3200 ft. below the surface and the presence of water carrying Blairmore presented some serious problems with regards to sinking of the shaft.

The demand for fertilizer is highly seasonal, with its peak occurring in February. It is, therefore, necessary to have storage facilities to accommodate several months production. It was deemed necessary to have 111,000 tons stored in the initial stage of the development of the mine, enough to fill all the cars in a railroad train 19 miles long.

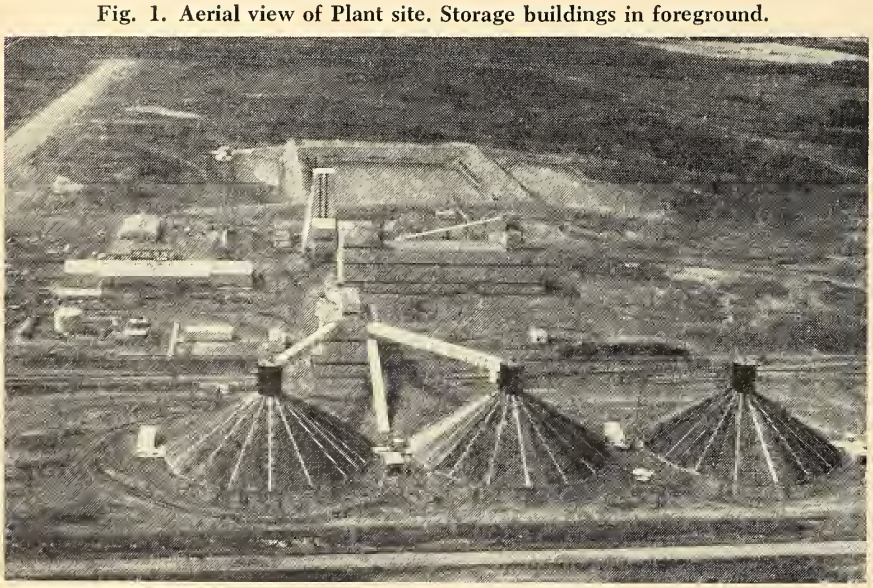
The common layout for storage of potash had been long oblong buildings in which walls were installed to divide the three types of material stored. On the project in Esterhazy it was decided to deviate from this procedure. Three separate buildings were called for, one for each size of potash, with provisions for two more buildings when the mine expanded. Fig. 1.

Each building was to contain 37,000 tons of potash. The potash would be brought from the drying ovens on conveyor belts to the apex of the structure. The material would then be spilled into the building to form a cone in the centre. Removal of the material would be effected through grisslies in the floor onto conveyor belts located in a tunnel below the storage floor. The belts would take the potash to the packaging plant where shipping would be made on railroad cars or trucks.

The problem which faced our company was to develop a design which would meet the outlined requirements. The pile to be covered consisted of a cylinder 204 ft. in diameter and 16 ft. in height, located below the ground level. On top of this the potash would form a cone 62 ft. high. The structural frame would have to be entirely outside of this space.

Several structural systems were investigated. First considered were glulam arches. These would have to span a total of 208 ft. and congregate in a common peak. This meant that the cladding would have to be slightly curved. It was specified that corrugated galbestos sheathing was required. A second proposed layout consisted of straight glulam beams arranged in the same manner as the arches. The cladding would now be straight but the structural members would become quite heavy. A third system consisting of a glulam "spaced frame" was developed.

Fig. 1. Aerial view of Plant site. Storage buildings in foreground.



The structures had to be designed for 40 p.s.f. Live Load and Wind Loads of:

20 p.s.f. up to 30 ft. above ground
25 p.s.f. from 30 ft. to 50 ft. above ground
30 p.s.f. for 50 ft. to 100 ft. above ground

In addition, head houses for conveyor equipment and the conveyor galleries had to be carried by the structure.

The "space frame" was submitted to the client; and after thorough comparison with buildings of other material it was chosen as the most suitable and economical.

The structure has 16 main ribs sloped towards the peak at an angle of 32°. The ribs rest on a tension ring built into the top of the foundation wall. The ribs do not meet at the top; but are stopped 12 ft. away from the apex. The ring which connects the ribs forms the perimeter for the operating floor. The ribs are divided into four parts by ring members. The trapezium thus formed by adjacent ribs and rings is then intersected by a diagonal member. A structure similar to the so called Schwedler dome is formed; one could call it a Schwedler cone.

The structure thus consists of 16 ribs, 64 ring members and 64 diagonals. Purlins having a spacing of 5 ft. 9 in. span from rib to rib. A total of 320 purlins are required for one building.

All the above material was made of glulam with the exception of some of the smaller purlins which were made of sawn timbers. Connections between the main structural members were made by means of steel plates, bolts and shear plates.

Design

For the purpose of the design the connection points were assumed to be hinges. This assumption is very similar to assuming hinges in the connection points in an ordinary truss. If further, the supports are considered to be hinges in the plane of the rib and held in place in other directions the structure becomes statically de-

erminate. The criterion is that the um of the members plus the reactions hall be equal to three times the anel points:

M + R = 3P

P = 5 × 16 = 80 Panel Points

R = 3 × 16 = 48 Reactions

M = 12 × 16 = 192 Members

192 + 48 = 3 × 80 = 240

From the formula it may be seen hat the structure could be considered s a four storey building; each storey eing statically determinate.

The loading is carried by the purns to the main ribs. The ribs are n turn considered to carry the load n cross bending to the panel points. Once a load has been brought to the anel points the stress analysis consists of three dimensional geometry as hown by Muller Breslau. The primary structural system will thus be ompression and tension members nd only the ribs will have moments reated by the purlin loads.

oadings

The dead load amounted to 7 p.s.f. f surface area. Live load was 40 .s.f. reduced for slope according to he National Building Code. This load as made unbalanced as indicated on he drawing. Full live load was aplied to the rib on the left and then reduced evenly to zero at the rib perendicular to the maximum. Wind oads gave all negative pressure when he slope factors from the National Building Code were used. The Wind load was assumed to act perpendicular to the roof surface. The distribution in magnitude is shown on Fig. 2. This load actually decreased the stresses in the members so the wind load was allowed to act as a positive pressure as well, using the same distribution.

Head House Loads

The mechanical equipment brought on vertical loads of a magnitude of 280 kips. This load was located slightly off centre from the line of symmetry. In addition, wind loads acting on the conveyor galleries produced horizontal forces which had to be carried by the structure.

Each of the loading conditions was treated separately and the stresses found for each member. The analysis had to be carried out for the following cases:

Dead Load
Conveyor Loads
Balance Snow Load
Unbalanced Snow Loads
Wind Loads

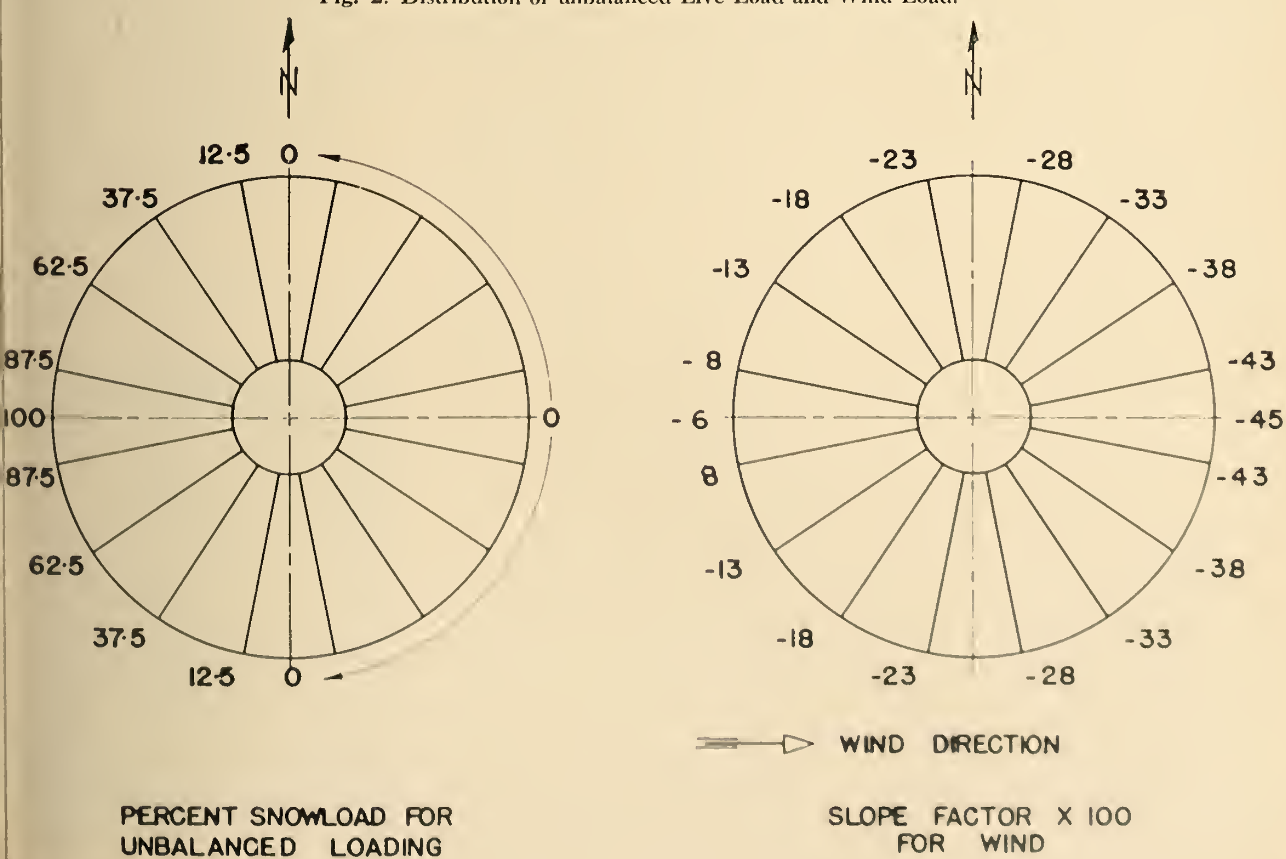
Since some of the loads could act from any direction whereas others were fixed in position, it was necessary to determine the maximum stress for each member and then find the combination which would give the most severe stress for the individual member.

Construction

The ribs had to be 7 in. x 28⅛ in. at the lower quarter of the length and 7 in. x 21⅛ in. in the second quarter. The third and fourth quarters required cross section of 5¼ in. x 16⅞ in. and 5¼ in. x 14⅛ in. respectively. The total length of the ribs was to be 104 ft. It was decided due to shipping problems to make the ribs in two pieces, joining them close to a panel point with a moment connection. Each of the half ribs was stepped to required section, a process easily accomplished in glulam. The ring members varied in size from 14½ in. x 15⅝ in. to 7 in. x 8⅛ in. The top ring had to have a cross section of 12½ in. x 16¼ in. because of heavy concentrated load from the head house. The heaviest diagonal was 5¼ in. x 19½ in. and the lightest was 5¼ in. x 11⅜ in. The purlins varied in sizes from 5¼ in. x 15½ in. x 39 ft. 6 in. glued-laminated members to 4 in. x 6 in. S4S.

It should be noted that the lower purlins were heavier in cross section than the ribs in the top quarter. Connections were complicated to detail, because both tension and compression had to be provided for. The forces in the connecting members had to be dissolved in the plane of the rib, using three dimensional geometry. Due to the corrosive action of the potash, the steel plates had to be at least ⅜ in. thick.

Fig. 2. Distribution of unbalanced Live Load and Wind Load.



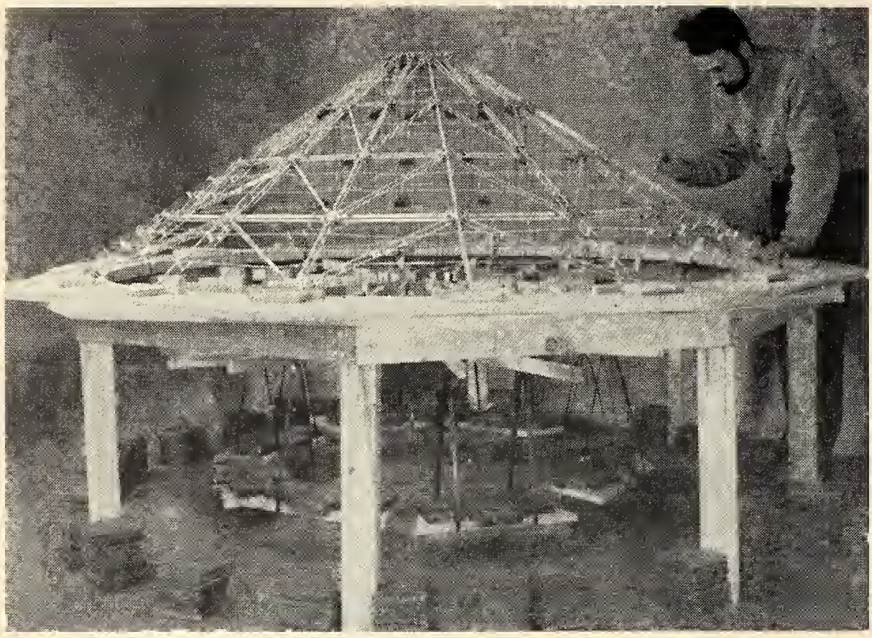


Fig. 3. 7 ft. Model. The loading devices can be seen below the table. The frame for the measuring gauges has not yet been placed.

Stability

The major problem in designing a structure of this nature is to ascertain its stability. Changes in the length of members caused by the primary forces can readily change the shape of the building. As the number of ribs increases the angle between panels becomes smaller. The number of ribs was chosen as a compromise between this angle and the length of the secondary framing members, the purlins. With 16 ribs the purlins were 40 ft. long at the bottom and the angle between adjacent panels was 11°. To determine the deflection of the panel points due to the many different loading conditions became next to impossible. Forty-eight differential equations of fifth order with 48 unknowns would have had to be solved. In addition, several modes of buckling could occur. For instance, every second rib could deflect inwardly and the remaining ribs could deflect outward from the line of symmetry. Or, every third rib might remain in its original position while the rib to the left would go in and the one to the right would buckle outward.

Rather than venture into this very cumbersome method of analysis it was suggested by Dr. R. F. Hooley of the University of British Columbia, that a comprehensive study of a scale model be undertaken.

The size of the model was chosen as a compromise between two requirements. On one hand connections were required to be big enough to be manufactured with sufficient accuracy. The connections in the model could not be larger in proportion than in the prototype. On the other hand the model had to be small enough that loadings could readily be simulated. A lineal ratio of 1 to 28 was chosen. Fig. 3.

The model was made of plexiglass having a modulus of elasticity of .45 x 10^6 p.s.i. The ribs were ¼ in. x 1 in. at the maximum cross section. The most difficult problem was to develop connections which would transfer the stresses and at the same time would not impair the accuracy of the model. A typical connection is shown on Fig. 4. At the points of connections the larger members were cut down to match the smallest member being connected. Two aluminum plates were placed one on each side of the members and the plates bolted together with ¼ in. bolts. The bolts were placed outside the plexiglass so that the joint acted in pure friction. It was found that the stresses could be so great that the friction would not suffice to hold the members in place. In order to overcome this condition, glue was placed on the plexiglass members and coarse sand sprinkled on the wet glue. This gave a stronger joint. In the model only the ribs were cut to the exact length. Rings and diagonals were kept shorter and the connection made up the difference. The model was assembled one panel at a time. Two ribs were placed in an accurately fabricated jig. Ring members and diagonals were placed and the connections were made while all members were held in a fixed position. This method assured that all panels were identical.

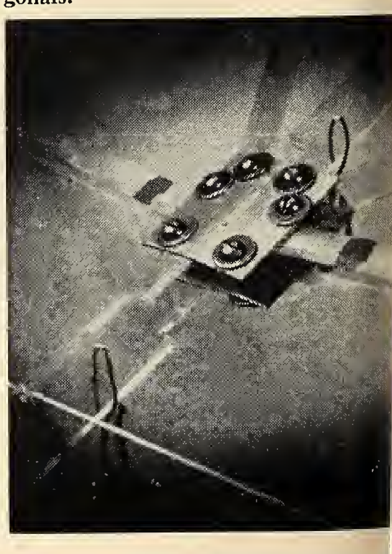
The model was placed on a specially constructed table. The table was 8 ft. in diameter with a hole in the centre of 6 ft. 6 in. This table simulated the tension ring of the foundation. Each rib was placed in an indentation in the table so that horizontal forces could be absorbed.

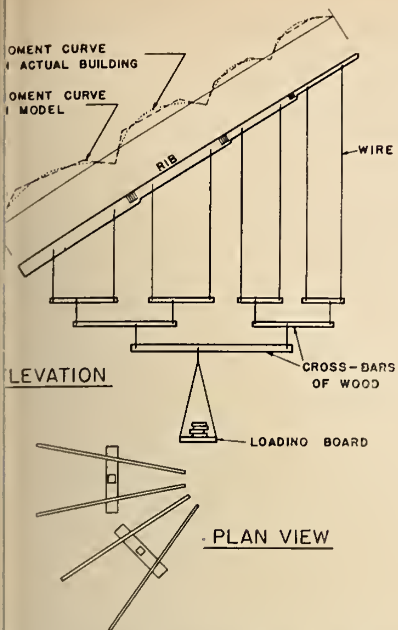
The purlins and diagonals are connected in the prototype to prevent buckling of the diagonals but in the model purlins were not used. Instead, strings were stretched from rib to rib. Three strings were used in the lower quarters, two in the next, and one in each of the top quarters. Small hooks were placed on each side of the panel points, in such a manner that the moment distribution in the rib would be very close to that of a U.D.L. loading. Fig. 5. A suspension system consisting of several levers was developed in order that the load placed on the platform below the table would be distributed to the panel points in the same ratio as the live load in the prototype. The platforms were connected to two ribs so that only eight places had to be loaded in order to distribute the load over the entire structure. Steel plates 5 in. x 5 in. weighing 3.4 lb. each were used for loading.

The deflection of the structure wa measured with gauges mounted on a frame independent of the structure The gauges measured to an accurac of 1/10000 of an inch. Three pane points were measured at each test Deflections were measured perpen dicular to the rib.

During the test it was noted tha curvature developed in the ring mem bers even though no loads were at tached directly to these members. A curvature gauge was used to asses the magnitude of the curve for differ ent loadings. Fig. 6. In addition, line were engraved on the members ad jacent to the panel points, in orde to detect any slippage of the join

Fig. 4. Typical connection at pan point. The main rib is reduced in siz to match the ring members and di gonals.





g. 5. Diagram showing load distribu-
n device.

odel Laws

Since the prototypes were to be ade of wood it might seem strange at the model was not made of the me material. However, it was felt at small imperfections in the wood uld cause a false picture when the eal ratio was 1:28. Plexiglass was und to be more homogeneous and as easy to cut and plane. It also s a modulus of elasticity which is ly one-quarter of that of Douglas . This meant that the load applied uld only have to be one-quarter of e load required for a model made wood. One disadvantage is that ien highly loaded, the plexiglass s a tendency to creep. However, it as not planned to leave the structure aded for long periods of time. The odel law would be:

$$\frac{p}{a \times e} = \frac{P}{A \times E}$$

P = load on prototype
A = cross section of member in ototype
E = modulus of elasticity of glulam
p = load on model
a = cross sectional area of similar ember in model
e = modulus of elasticity in plexi- ass

$$p = \frac{a}{A} \times \frac{e}{E} \times P$$

$p = .000317P.$

1 lb. on the model would be equal approximately 3.2 kips on the pro- type.

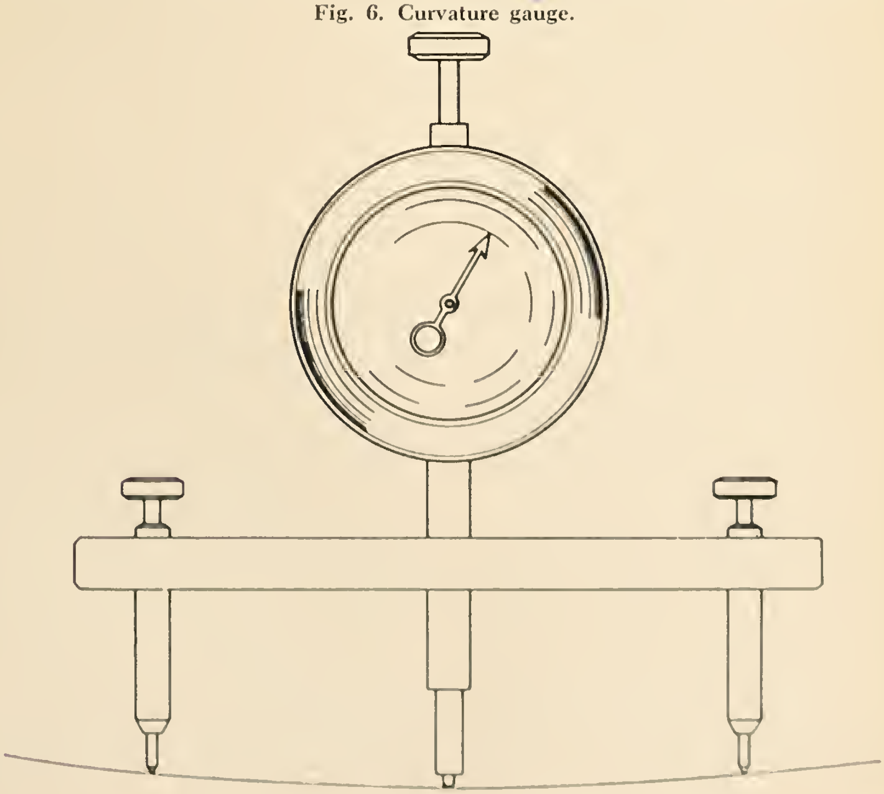
sting

In a test of this nature one would interested in trying several loading nditions. It is therefore important at the ultimate load can be assessed without destroying the model. In the case of columns, the critical loads can be determined by plotting deflection divided by load as ordinate and deflections as abcisse in an XY system. This is shown by Timoshenko in his book "Theory of Elastic Stability". The same straight line relationship was observed in testing of this model. The ultimate load could therefore be determined by assessing the slope of the line obtained in the co-ordinate system. The test commenced by taking the readings of the three gauges. Then a load was placed on each of the loading platforms. Readings were taken for each load increment. As the test progressed the deflections were plotted so that the ultimate load could be predicted. When the load approached the ultimate load, care was exercised in placing the additional loads. Often loadings were carried to within 10% of the ultimate load. However, in some cases the testing did not go as planned. In one case, a joint slipped causing two panels to fold in. The load had to be removed and repairs carried out. In another case the load touched the floor before the full load had been applied. Uniform loading was applied three times. The additional information regarding bending forces in the ring members was collected during the uniform distributed load test. In a good many cases the diagonals could be observed to "snake" between the strings simulating the purlins. The maximum total load applied amounted to 760 lb.

The loading system did not provide for horizontal loads to be placed on the model to simulate wind forces. Instead it was decided to test the model for severe unbalanced loading conditions. First a load similar to the unbalanced design load was placed on the structure very gently. The graph gave good straight lines with an indicated ultimate load much above that of the U.D.L. loading. In the next test only two ribs were loaded. Two gauges gave good consistent readings again with an ultimate load above the U.D.L. The third test consisted of one-half the structure loaded. When a total load of 325 lb. was placed the model was shaken severely to see whether an impact loading would collapse the structure. This did not happen. A last unbalanced loading test was conducted with four adjacent ribs loaded. The results obtained were similar to those of previous tests.

In some of the tests one gauge gave quite inconclusive readings, whereas the other two gave clear answers. The reason for one gauge being inconsistent might be explained by the fact that the gauge was placed at a neutral point, or by some inaccuracy in the manufacturing of the model. It was noted that in all the unbalanced tests the ultimate load was in excess of the balanced load indicating that the structure was not vulnerable to those conditions. This was contrary to expectations because stress analysis gave very high stresses for unbalanced

Fig. 6. Curvature gauge.



Loading PL per Platform		$\delta_0 = 832$	$P_0 = 0$		$\delta_0 = 832$	$P_0 = 3$		$\delta = 833$	$P_0 = 8$	
		$\delta - \delta_0$	$P - P_0$	$\frac{\delta - \delta_0}{P - P_0}$	$\delta - \delta_0$	$P - P_0$	$\frac{\delta - \delta_0}{P - P_0}$	$\delta - \delta_0$	$P - P_0$	$\frac{\delta - \delta_0}{P - P_0}$
Zero	832	0	0							
3	832	0	0	0	0	0				
8	833	1	8	0.125	1	5	0.200	0	0	
12	835	3	12	0.250	3	9	0.333	2	4	0.500
16	837	5	16	0.312	5	13	0.385	4	8	0.500
20	841	9	20	0.450	9	17	0.530	8	12	0.668
24	848	16	24	0.668	16	21	0.762	15	16	0.938
* 28	924	92	28							
30	935	103	30							

*One member slipped at joint

Fig. 7. Readings on Gauge #1 during Test #1 (balanced loading).

loading. However, the model gave sufficient data to assess the factor of safety against buckling. The result registered on one gauge under balanced loading is shown on Table 1. The table shows the number of plates per platform in column (1). Column (2) gives the reading on gauge No. 1. The next three columns give the increase in the deflection readings and the increase in loading, using the first reading as reference marks. The three next columns give the same values when three plate loading is used for reference. The last three columns show the figures when an eight plate loading is used as reference. The Graph (Fig. 8) shows how the values form a straight line in the coordinate system.

The factor of safety against buckling was found to be 2.1 ± 0.4.

Model Equal Prototype?

Could it be said that the model duplicates conditions in the prototype? Not exactly. The connections were possibly somewhat stiffer in the model than in the prototype. On the other hand the cross section of the ribs was reduced at the connection point in the model; whereas the cross section was carried right through in the prototype. Also the number of purlins was much greater in the prototype, giving stronger bracing of the ribs. The most important differences were in the head house. This was 30 ft. high and rigidly connected to the top ring. The floor and the roof were constructed to form strong diaphragms which distributed the forces more evenly at the top of the rib.

Ring Members

As mentioned, it was observed that the rings did deflect at high loads. In order to maintain the same factor of safety in the prototype as in the model, this moment had to be taken into account. It was found that the moment amounted to 338 in. kips for the lower ring member and it was therefore found necessary to increase the member size.

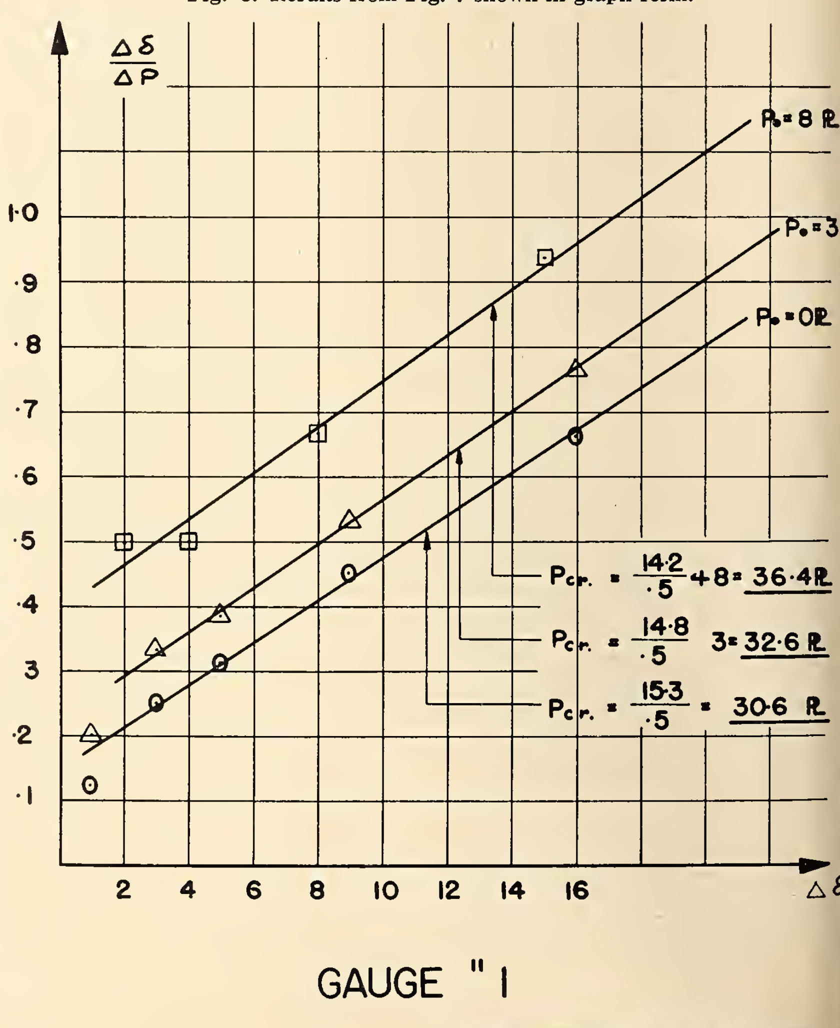
Shop Drawings

The detailing of this structure commenced with accurately locating the connection points using three dimensional coordinate system. The tolerance allowed was 1/32 in., so the calculations were carried to 1/64ths. The model was used frequently to visualize problems in detailing. The main structures were identical in the three buildings but the arrangement in the head houses varied. The head houses consisted of glulam columns with ½ in. plywood sheathing fastened on the inside and the outside of the column. The conveyor galleries landed on a steel frame bolted to the glulam. Co-ordination of drawings had to be carried out with several other firms.

Manufacturing

All the glulam was produced according to the Canadian Standard Association Specification 0122. Only waterproof glue was used. All quality control requirements called for by the Canadian Institute of Timber Construction were adhered to. In order to test all patterns for the members and jigs for the steel connections, two pieces of each kind were made. Two panels were assembled in the yard

Fig. 8. Results from Fig. 7 shown in graph form.



f the plant. Dimensions and angles vere checked before the mass production was started. The quality control department was instructed to pay xtra attention to framing.

ire Retardant Treating

The structural members were pressure treated with a commercial fire etardant. These were the first major ructures in Canada to receive this eatment. The retardant is a pressure treatment which reduces the ame spread rating to below 25. The wner's insurance company called for ll purlins, diagonals and ring members to be treated. The continuous iain ribs did not have to be treated. Vhen one considers the facts that ome purlins had a larger cross secon than the top of the main rib and iat the purlins were spaced 5 ft. 9 in. part it seems strange that this ivision was made. Other fire experts ave expressed the opinion that they ould have called for ribs and iagonals to be treated but not the olated purlins and rings. This points the need for further study of fire equirements and particularly the adantages of "fire stable" glued-laminted material.

rection

The shipment of the material was ade in flat cars directly to the jobte. While the unloading of the 28,-00 pieces took place, the base plates ere brought into position. The founations were, despite their huge size, und to be very exact. Not one of e almost 300 anchor bolts was out y more than 1/16 in. The erection llowed the same sequence as the ssembly of the model. Eight panels ere assembled and placed with the oints toward the center of the building. A column was attached by means of a hinge to the ring #3. Two cranes lifted the whole panel and raised it into position. The pins were driven at the base connection. The column, a 10 in. pipe reinforced with span stays was then placed in a vertical position. The cranes could now be freed and moved over to the next panel. When the eight panels were in place the intermediate members were placed, starting from the top. Members were lifted by crane standing on the outside of the building. The columns were raised or lowered by hydraulic jacks to ease the placing of the members. This was necessary because the top of the panel deflected 9 in. when supported as described. When all members were in place bolts were tightened and placing of purlins commenced. By using this method of erection it was possible to avoid scaffolding entirely. The head houses were assembled in four pieces on the ground and hoisted through the center ring. An access stair was erected on the outside of the building and application of sheathing constituted the last phase of the job.

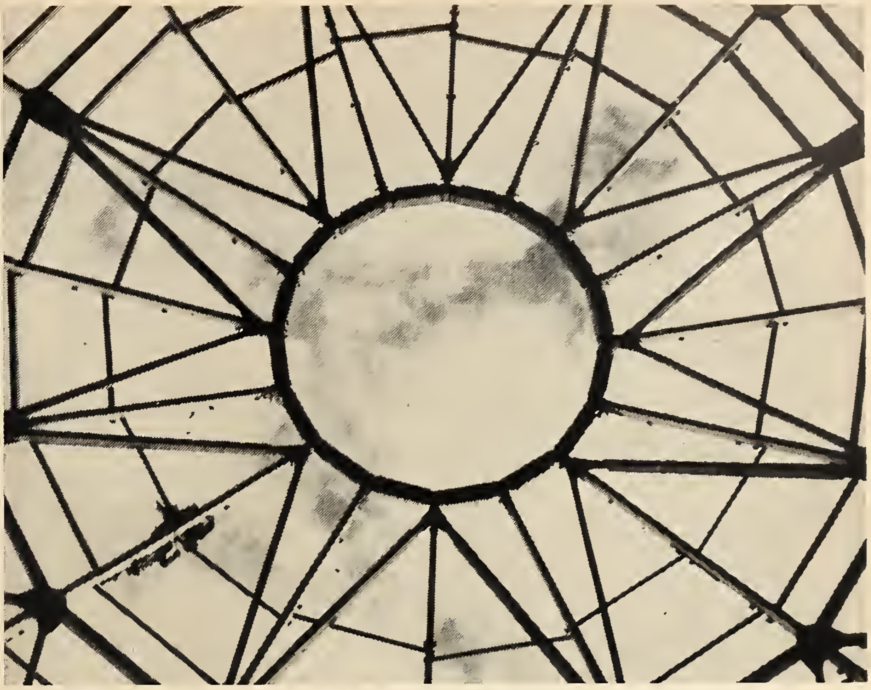


Fig. 9. Inside view of the structure. Men in process of placing purlins.

Fig. 10. Building with Head Houses. Sheathing being applied.

Statistics

The structures contained:

1,630	structural members
7,250	bolts and lag screws
9,300	shear plates
3	acres of Galbestos sheathing
9,000	lbs. waterproof glue
51,500	lbs. fire retardant salts
112,000	lbs. steel for connections

It took 16 fully loaded railcars to ship the pre-fabricated buildings to the jobsite.

Summary

The use of glued-laminated material in these buildings resulted in a very economical structure. In them glulam showed its versatility and the ease with which it may be used to erect complicated structural systems. The fact that glulam has high resistance to atmosphere which would create corrosion in other materials was a virtue added to its economy.

The structures presented a challenge to the company and the solution developed was found to be entirely satisfactory, not only to the owner, but to all associated with this project. EIC

Automation and Control Engineering in Canada

Engineering Applications of Analog Computers

T. W. McDonald,
Assistant Professor, Mechanical Engineering

P. N. Nikiforuk,
Associate Professor, Mechanical Engineering
University of Saskatchewan

Presented at the 75th E.I.C. Annual General Meeting, Vancouver, May 1961.

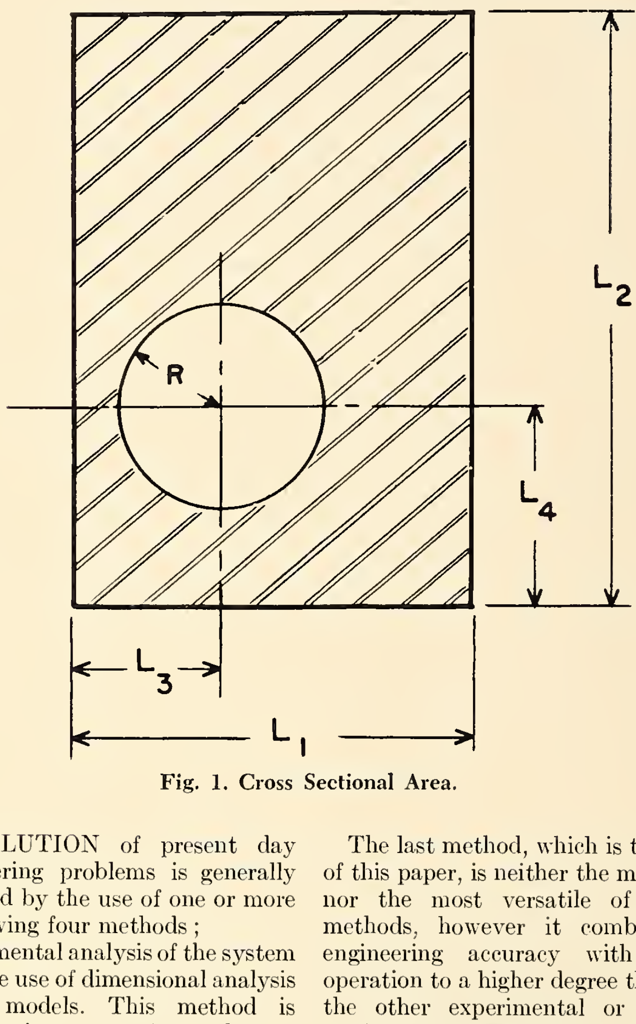


Fig. 1. Cross Sectional Area.

THE SOLUTION of present day engineering problems is generally accomplished by the use of one or more of the following four methods;

1. Experimental analysis of the system including the use of dimensional analysis and scale models. This method is usually very time-consuming and often is impractical.
2. Mathematical solution of the governing equations. This gives the most useful results, however it is also the least versatile method.
3. Numerical solution of the governing equations. This is the most versatile of all the methods, however it is also very time-consuming unless a large number of similar problems are to be solved on a digital computer.
4. Experimental analysis of a mathematically analogous system which is more convenient to work with than the original system. The physical properties of the two systems being related through the use of dimensional analysis.

The last method, which is the subject of this paper, is neither the most precise nor the most versatile of the four methods, however it combines good engineering accuracy with ease of operation to a higher degree than any of the other experimental or numerical methods. It also gives an excellent insight into the behaviour of the physical system since the effect of varying any of the system parameters may be observed immediately.

Since electric circuits can be set up which are mathematically analogous to any given physical system and since electrical potentials may be easily and accurately measured, electric analog computers are used more extensively than any other type. Because of this versatility only electric analogs are discussed in this paper. For convenience, these computers have been classified as being either "Special Purpose" or "General Purpose". The former are designed to solve certain specified equations whereas the latter are capable of solving almost any system of equations, the only limitation being the size of the computer available. These two types of analogs supplement one another in that most of the problems readily solved by special purpose analog computers would require a very large, expensive, general purpose unit for their solution.

This paper is concerned primarily with the applications of conducting sheet and resistance-capacitance network special purpose analogs and the d.c. electronic analog computer. Typical engineering applications are discussed in some detail and this is followed by a comparison as to accuracy, flexibility and ease of programming.

SPECIAL PURPOSE ANALOGS

In order that systems be mathematically analogous they must obey the same basic differential equation and have analogous boundary and initial conditions. Under these conditions the systems may be non-dimensionalized in such a way that the resulting equations and boundary conditions are identical.

Table I lists three frequently occurring differential equations along with some of the engineering fields in which they arise. Since all the systems governed by the same equation are analogous, a solution of one constitutes a solution for all. The criterion used in selecting an electrical system as the analog discussed in this paper is its versatility and the ease with which the system may be set up, the boundary and initial conditions met, and the necessary measurements made.

To solve the equations in Table I, it is necessary to work with a continuous medium. Electrically this is not feasible if the problem is transient and hence requires a continuous medium having both resistance and capacitance in the desired proportions. This difficulty may be by-passed by approximating the given equation by writing it in finite difference form. This permits the use of lumped elements such as resistors and capacitors in the desired proportions. The use of electric networks to simulate

TABLE I

Some Mathematically Analogous Systems

asic Equations : $\nabla^2\phi = 0 \ldots (1)$, $k\nabla^2\phi = g\phi + f \ldots (2)$,
$\nabla \cdot k\nabla\phi = C(\partial\phi/\partial t) + g\phi + f \ldots (3)$

Physicial Phenomenon	*Eq'n*	*Symbol Interpretation*				
		ϕ	k	C	g	f
lectrical Conduction	3	$V(x,y,z,t)$	$k_e(x,y,z)$	$C_e(x,y,z)$	$G_e(x,y,z)$	$i'''(x,y,z)$
	2	$V(x,y,z)$	k_e	—	$G_e(x,y,z)$	$i'''(x,y,z)$
	1	$V(x,y,z)$	—	—	—	—
eat Conduction	3	$T(x,y,z,t)$	$k_t(x,y,z)$	$\rho C_p(x,y,z)$	$h(x,y,z)$	$q_t'''(x,y,z)$
	2	$T(x,y,z)$	k_t	—	$h(x,y,z)$	$q_t'''(x,y,z)$
	1	$T(x,y,z)$	—	—	—	—
lass Diffusion	3	$\rho(x,y,z,t)$	$D(x,y,z)$	1	0	$m'''(x,y,z)$
	2	$\rho(x,y,z)$	D	—	0	$m'''(x,y,z)$
	1	$\rho(x,y,z)$	—	—	—	—
luid Flow Through a Porous Medium	3	$P(x,y,z,t)$	$(p/\nu)(x,y,z)$	$\rho K f_p(x,y,z)$	0	0
	1	$P(x,y,z)$	—	—	—	—
lembrane Deformation Due to Pressure	2	$Z(x,y)$	1	—	0	P/τ'
orsional Shear Stress	2	$\phi(x,y)$	1	—	0	$-2G\theta$
armonic Vibrations Elastic Membrane	2	$Z(x,y)$	1	—	$-m''w^2/\tau'$	0
haft in Torsion	2	$\theta(z)$	1	—	$-J'w^2/G$	0
eneral	2	$U(x,y,z)$	1	—	$-\rho w^2/E$	0
leal Fluid Flow	1	$\phi(x,y,z)$	—	—	—	—

continuous system also makes it simple) analyse problems involving non- otropic, non-homogenious media.

There are two continuous medium ectric analogues that are used ex- usively to solve Laplace's and Pois- on's equation. For three-dimensional roblems electrolytic tank models are sually used while conducting sheet nalogs provide a very simple method of lving two-dimensional problems. Since he analog approach to the use of both these systems is identical, only the simpler conducting sheet analog will be considered here. For further information on the techniques involved and the equipment required in the use of electrolytic tanks, the reader may refer to the book by Karplus.[1] Paschkis[2] gives an extension of the electrolytic tank technique to the solution of transient problems.

The Conducting Sheet Analog:

As its name implies this analog utilizes the electrical properties of a homogeneous, uniform, isotropic sheet of conducting material and is used to solve Laplace's or Poisson's equations in one or two dimensions. The potential distribution throughout a system is obtained by determining the position of a number of equipotential lines on the analog by means of a probe which is moved over the surface of the conducting paper.

The factors which control the accuracy of conducting sheet analog solutions are :—

(i) the degree of uniformity of the conducting paper ;

(ii) the degree of isotropy of the conducting paper ;

(iii) the sensitivity of the probe circuit ;

(iv) the accuracy to which the boundary conditions are met.

Karplus[1] has tabulated the properties of various conducting sheet materials and has indicated any special precautions which should be considered for each material used. With care, the results may be expected to be within 5% of the correct values.

Since the voltage distribution throughout a conducting sheet satisfies Laplace's equation, any problem governed by equation (1), (Given in Table I) may be solved by cutting the conducting sheet to the desired shape and then applying a voltage distribution along the boundaries which is analogous to the potential distribution along the system boundaries.

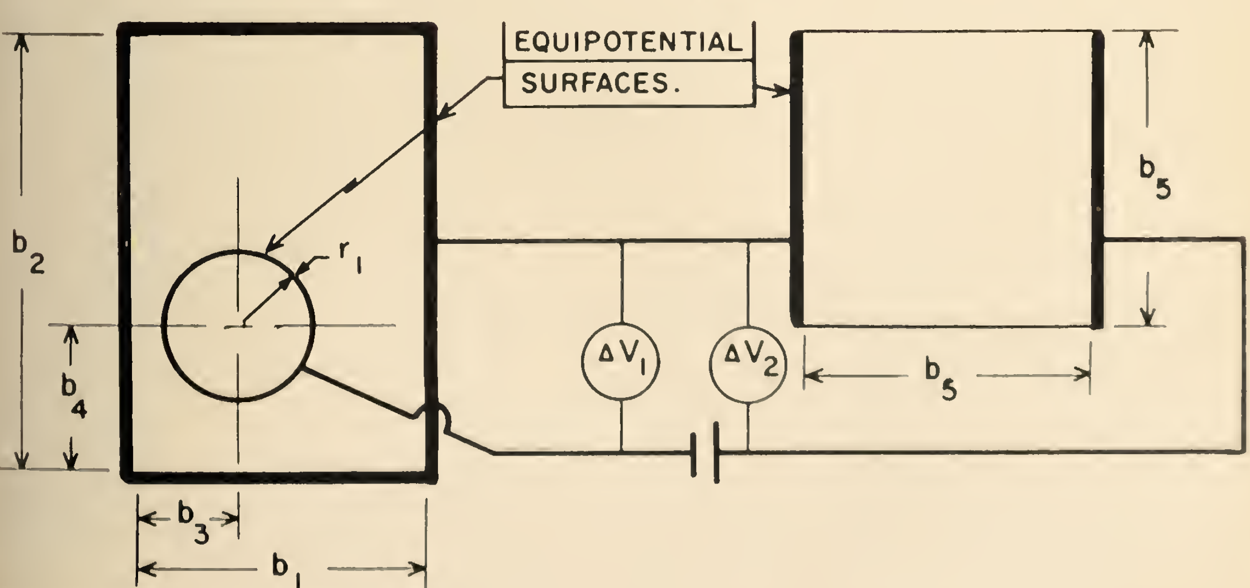
Problems satisfying equation (2) may be solved using a conducting sheet analog by three different methods, two of which are similar.

Any variable ϕ satisfying

$$\Delta^2\phi = C \text{ (a constant)} \qquad (4)$$

may be transformed into a variable ψ which satisfies

Fig. 2. Fluid Flow Analog Circuit.



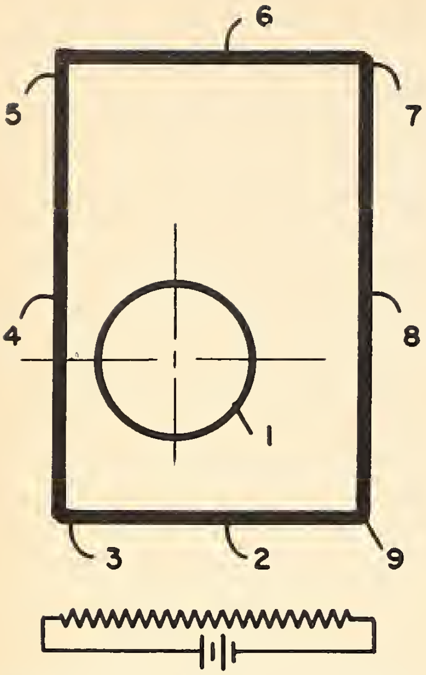


Fig. 3. Torsional Shear Stress Analog Circuit.

$$\Delta^2\psi = 0 \quad (5)$$

by the transform

$$\phi = \psi + C(a_0x^2 + a_1x + a_2xy + a_3y + a_4y^2 + a_5) \quad (6)$$

where the constants a_i may be arbitrarily chosen with the only limitation being $(a_0 + a_4) = \frac{1}{2}$. The values for the a_i are generally selected to provide the simplest transformed boundary conditions. The solution of the original equation is thus obtained by solving for ψ using the conducting sheet analog with the transformed boundary conditions then calculating ϕ from these results using equation (6). The only approximations that may be involved in this procedure are in the electrical simulation of the transformed boundary conditions. This is usually accomplished by painting along the boundary with a conducting paint and then embedding a number of terminals in the paint.[3] Any desired voltage distribution can then be approximated by applying an appropriate voltage to each of the terminals.

The other two methods are approximate but they give the values of ϕ directly and can be used without difficulty to solve the general equation (2) as well as equation (4). The electrical system that is directly analogous to equation (2) is a conducting sheet with uniformly distributed but varying current leakage or gain. Since it is usually not feasible to have a uniformly distributed current source or sink[4], the conducting paper may be supplied with localized current sources at the midpoints of imaginary grid areas covering the analog. The resulting voltage distribution is the required solution of ϕ

A simpler and more accurate method is to provide a distributed current source over one single grid area at a time measuring the resulting voltages throughout the analog for each position of the current source.[5] The sum of the readings at any given location is the value of ϕ for that position. The magnitude of the current supplied at each grid point is made proportional to the magnitude of $[f(x,y) + g(x,y)\phi]$ in equation (2).

Problems involving a composite system may be solved using a conducting sheet by cutting portions of the analog sheet into a mesh which gives the required resistance.[6,7]

Conducting sheet analogs are also very useful in determining two-dimensional geometric shape factors "S" as defined by

$$\text{Flux} = q = SLk\Delta\phi_b \quad (7)$$

for systems with equipotential boundaries. L represents the dimension normal to the cross section being studied.

The following examples illustrate some of the uses of a conducting sheet analog.

Mass Flow Through a Porous Medium: Consider the problem of determining the steady state mass flow rate of a fluid through a homogenious, porous medium having the cross-section shown in Fig. 1 where the inner and outer boundaries are maintained at a constant pressure.

If the pressure distribution throughout the body is not required this problem is simply one of finding the geometric shape factor "S" for the given cross section. The circuit used to determine S is shown in Fig. 2. The conducting sheet analog dimensions "b_i" are made proportional to the corresponding dimensions "L_i" of the given shape and equipotential boundaries are provided as shown. A square, which has a shape factor $S_s = 1$, is cut from the same conducting sheet and placed in series with the analog as shown. The shape factor may then be calculated from the measured quantities ΔV_1 and ΔV_2 as follows. By definition of the shape factor

$$i = Sk_eL\Delta V_1 = S_sk_eL\Delta V_2 = k_eL\Delta V_2$$

thus,

$$S = \frac{\Delta V_2}{\Delta V_1} \quad (8)$$

The mass flow rate of the given fluid per unit depth of the cross section may then be calculated from

$$\dot{m}' = S(p/\nu)\Delta P_b \quad (9)$$

where S is obtained from equation (8).

The conduction heat transfer through this same shape could also be easily calculated from the equation

$$q_t = k_tS\Delta T_b \quad (10)$$

The other phenomena listed in Table I which satisfy equation (1) can be treated in a similar manner.

Torsional Shear Stress:[8,5] The determination of the torsional shear stress within a cylinder having any arbitrary cross section resolves itself into the solution of Poisson's equation for the torsional shear stress function ϕ. To illustrate this problem consider a shaft having the cross section shown in Fig. 1.

Using the transform technique, let

$$\phi = \psi - G\theta(x^2 + y^2) \quad (11)$$

where the origin is taken at the center of the circle. This particular transform was chosen so that the transformed boundary condition for the circle remains an equipotential surface.

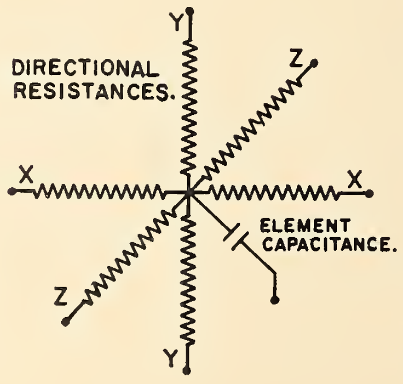
The required circuit for this solution is shown schematically in Fig. 3 where nine terminals have been indicated to roughly approximate the required transformed boundary conditions. The required voltages to be supplied to these points may be obtained by tapping off a resistance wire placed across a battery.

The transformed boundary conditions are such that

$$\left.\begin{aligned}
\psi_1 &= -G\theta R^2 \\
\psi_2 &= -G\theta\left[\left(\frac{L_1}{2} - L_3\right)^2 + (L_4)^2\right] \\
&\;\;\vdots \\
\psi_7 &= -G\theta[(L_1 - L_3)^2 + (L_2 - L_4)^2] \\
&\;\;\vdots
\end{aligned}\right] \quad (12)$$

The voltages to be applied at terminals 1 to 9 must be proportional to the calculated values of ψ at each of the points. Non-dimensionalizing both sys-

Fig. 4. Lumped Element Electric Analog Circuit.



ems by dividing each boundary value by the corresponding maximum boundary value (which happens to be at point 7 in this case), the following relations re obtained

$$\frac{V_1}{V_7} = \frac{\psi_1}{\psi_7}, \frac{V_2}{V_7} = \frac{\psi_2}{\psi_7}, \ldots \frac{V_9}{V_7} = \frac{\psi_9}{\psi_7} \quad (13)$$

V_7 may be any arbitrarily selected onvenient voltage. The transformed tress potential at any point is thus elated to the voltage at that point by he equation

$$\psi = \frac{V}{V_7}\psi_7 \quad (14)$$

The true stress potential "ϕ" at any point may then be calculated using quation (11).

The torsional stress "τ" at any point s given by $d\phi/dn$, where n is the direction normal to the isopotential curves, nd hence the maximum torsional tress occurs where the lines of constant ϕ are closest together.

Note that the magnitude of the imensionless terms in equation (13) re dependant only on the geometry of he system, hence the analog results btained are applicable to the solution f problems involving any of the other henomena listed in Table I that obey quation (4). The only difference occurs n the value of ψ_7 in equation 14 and in he final calculation of ϕ using equation 11) since the value of the constant in quation 4 will vary from case to case.

The Resistance-Capacitance Network Analog[9]:

This analogue compliments the use f the conducting sheet analog in hat while it may be used to solve any f the equations in Table I, it finds its rimary use in the solution of the ransient problems governed by Eq. (3).

The use of any network analog requires that the original system be subdivided into a number of discrete elements. The properties of each of these lements is then simulated in the nalogous electric circuit. The subdivision of any continuous medium is athematically equivalent to approximating the governing differential equation by its corresponding finite difference equation. Unfortunately, the rror involved in this discretizing process annot be estimated until after a test as been run. In order to minimize this ype of error smaller elements should be sed in regions where rapid changes in he potential gradient are to be expected. Other sources of errors are iscussed by Paschkis and Heisler[10].

In the analogous electric circuit apacitors are the analog of the storage apacity for each element while electrical resistors are the analog of the esistance offered by the medium to the flux through the element in any direction. Thus any three-dimensional lumped element will appear in its analogous electric network as shown in Fig. 4.

The size of the various resistors and capacitors for any given lumped element for any given problem may be determined as follows. In general the relationship between the flux in the x direction and the potential is given by

$$q = -kA\frac{\partial\phi}{\partial x} \quad (15)$$

The flux through a small element may be approximated by

$$q = -kA\frac{\Delta\phi}{\Delta x} = -\frac{\Delta\phi}{R} \quad (16)$$

where the resistance R is defined by this equation. The rate of storage in any small element is given by

$$q = C\frac{d\phi}{dt} \quad (17)$$

where C represents the storage capacity of the element. The corresponding electrical equations for current flow through a resistor and storage by a capacitor are respectively

$$i = -\Delta V/R_e \quad (18)$$

and

$$i = C_e dV/dt_e \quad (19)$$

The five terms, i, V, R_e, C_e and t_e in equations (18) and (19) may be non-dimensionalized by letting

$\overline{\Delta V} = \Delta V/\Delta V_m$ volts/volt (20a)

$\overline{R_e} = R_e/R_{em}$ megohms/megohm (20b)

$\overline{C_e} = C_e/C_{em}$ microfarads/microfarad (20c)

From equation (18)

$\bar{i} = iR_{em}/\Delta V_m$ amperes/ampere (20d)

and by equating (18) and (19)

$\bar{t_e} = t_e/R_{em}C_{em}$ seconds/second (20e)

Equations (16) and (17) may be similarly non-dimensionalized using the corresponding terms for the physical system. As a result the following relationships are obtained.

$$\Delta\phi/\Delta\phi_m = \overline{\Delta\phi} = \overline{\Delta V} = \overline{\Delta V}/\Delta V_m \quad (21a)$$

$$R/R_m = \bar{R} = \bar{R_e} = R_e/R_{em} \quad (21b)$$

$$C/C_m = \bar{C} = \bar{C_e} = C_e/C_{em} \quad (21c)$$

$$qR_m/\Delta\phi_m = \bar{q} = \bar{i} = iR_{em}/\Delta V_m \quad (21d)$$

$$t/R_mC_m = \bar{t} = \bar{t_e} = t_e/R_{em}C_{em} \quad (21e)$$

Since there are five electrical terms and only two equations relating them, values may be arbitrarily chosen for the electrical non-dimensionalizing quantities, V_m, R_{em} and C_{em}. As a result values are selected for them comensurate with the available potential supply, resistors, capacitors and the desired time constant which is given by the product $R_{em}C_{em}$. The magnitude of this product governs the time required for a solution and hence the type of input power supply and output recording device required.[11] If the time constant is small, electronic function generators and oscilloscopes must be used. If the time constant is large the input may be generated manually using a slide wire potentiometer and battery and the output measred by a high impedance voltmeter or recorder.

The resistance capacitance network analogue at the University of Saskatchewan is capable of simulating 50 lumped elements. Zero to five megohm variable resistors are available as well as precision capacitors in .05 microfarad increments from .20 microfarads to 15 microfarads or more if necessary. Thus electrical time constants are available from zero to over one minute. An electrical system having a time constant of a few seconds can usually be handled manually.

Table II gives the interpretation of the terms in equations (16) and (17) for various physical phenomena along with typical engineering units.

The following examples illustrate some of the uses of a resistance-capacitance electric network.

TABLE II

Network lumped-element analogies

Physical Phenomenon	*Flux q*	*Resistance R*	*Potential ϕ*	*Capacitance C*
Electrical Conduction	i amperes	R_e megohms	V volts	C_e microfarads
Heat Conduction	q BTU/hr.	$R_t = \frac{\Delta x}{k_t A}\frac{\text{hr. F}}{\text{BTU}}$	T F	$C_t = \rho C_p (\Delta \text{Volume}) \frac{\text{BTU}}{\text{ft}^3 \text{F}}$
Mass Diffusion	m lb.$_m$/hr.	$\frac{\Delta x}{DA}\frac{\text{hr.}}{\text{lb.}_m}\frac{\text{lb.}_f}{\text{ft}^2}$	P_p lb$_f$/ft^2	$\rho K(\Delta \text{Volume})\frac{\text{lb}_m}{\text{ft. lb}_f}$
Flow Through a Porous Medium	m lb.$_m$/hr.	$\frac{\Delta x \mu}{\rho A}\frac{\text{hr.}}{\text{lb.}_m}\frac{\text{lb.}_f}{\text{ft}^2}$	P lb$_f$/ft^2	$\phi\rho K(\Delta \text{Volume})\frac{\text{lb}_m}{\text{ft. lb}_f}$

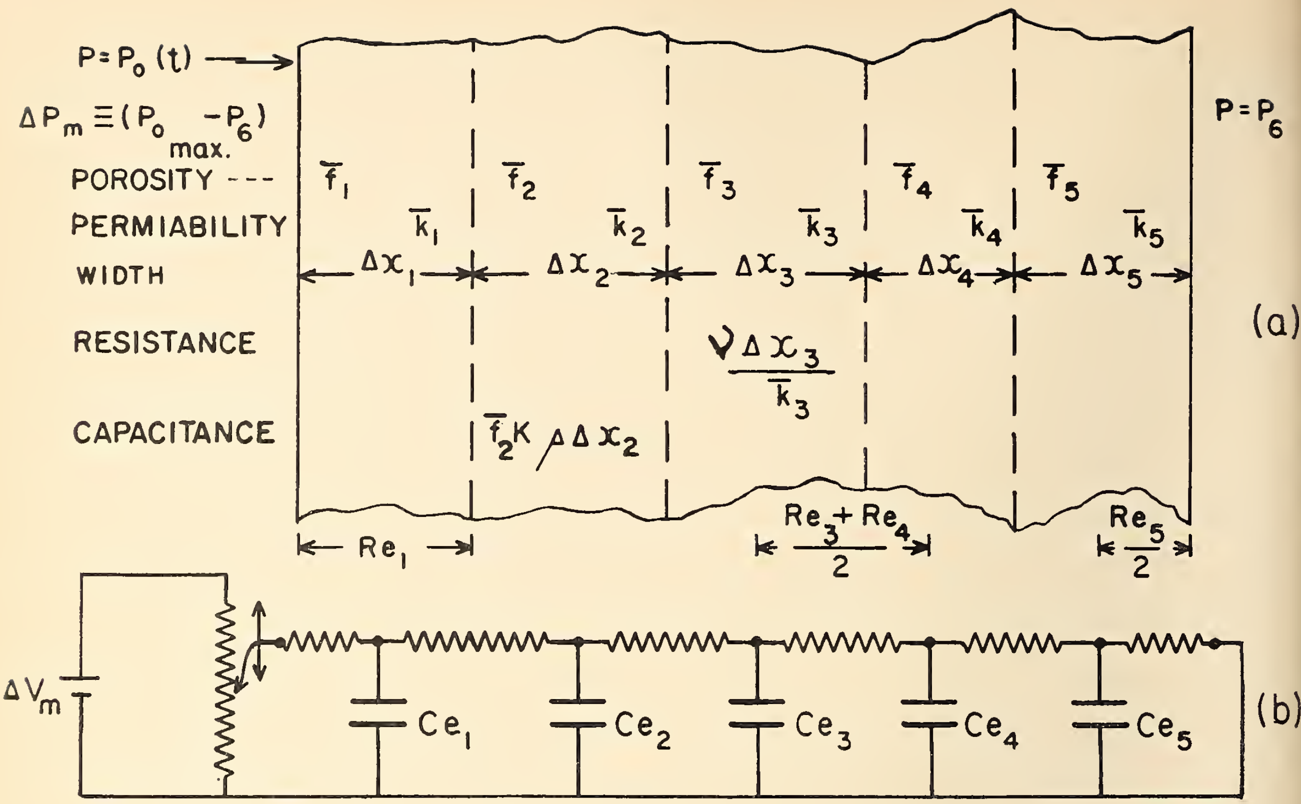


Fig. 5. Transient Fluid Flow System (a) and Analog Circuit (b).

Transient Flow Through a Porous Medium: Consider the one-dimensional flow of a fluid through the porous medium shown in Fig. 5(a) due to a pressure variation at one surface while the pressure remains constant at the other. The medium may have spatially varying porosity and permiability without increasing the difficulty of the problem.

The medium has been shown subdivided into five laminations. The average value of the medium properties may be calculated for each lamination hence the resistance to flow and the storage capacity of each lamination may be calculated as indicated in Table II with the area taken as unity.

The equivalent electrical network is shown in Fig. 5(b). The relationship between the various electrical and flow terms are as given in equations (21) where $\Delta\phi_m = \Delta P_m$ may be any characteristic pressure magnitude. For this case ΔP_m could conveniently be taken as the pressure difference across the medium at any given time. Let it be the maximum pressure difference that occurs. ΔV_m, which may have any arbitrary magnitude, is then the maximum voltage difference applied to the circuit. R_m and C_m may be arbitrarily selected as the flow resistance and capacitance of the first lamination. The magnitudes of R_{em} and C_{em} should be selected to give a convenient electrical time constant ($R_{em}C_{em}$). For the circuit shown, this should be such that the operator has sufficient time to stimulate the desired pressure variation by using the slide wire potentiometer.

The mass flow rate through unit area at either surface may be obtained by measuring the corresponding electric current with an ammeter, then solving for the mass flow rate using equation 21(d). The change in the mass of fluid stored in any lamination from the initial state to any later time may also be obtained by using the equation

$$(m - m_{initial}) = C(P - P_{initial}) \quad (22)$$

where C is the storage capacity of the lamination in question.

The pressure difference ($P - P_6$ at the mid-point of each element may be calculated by measuring the voltage at the corresponding point in the electric circuit then using equation 21(a).

Heat Transfer: To illustrate this phenomenon consider the problem of determining the refrigeration capacity required to reduce the temperature in a room containing a mass M a given number of degrees in one hour. To simplify this problem consider the case where all the walls and ceiling are of the same construction and material, and hence they may be grouped together and treated as one surface. The floor will be considered as a separate flow path.

The room is shown schematically in Fig. 6(a) and the analogous electric circuit in Fig. 6(b).

The outside air temperature surrounding the walls and the ceiling is represented by T_3 and the corresponding heat transfer coefficient by h_3. The outside floor surface temperature is given by T_2. The inside heat transfer coefficient h_1 must be estimated and held constant throughout any given test run. However, the effect of different coefficients may be determined by repeating the tests using different values of h_1.

The walls have been divided into four laminations and the floor into three laminations. The mass M is shown treated as a single lumped element. The accuracy of the system may be improved by using smaller and hence more lumped elements. In particular, laminations adjacent to the room surface should be small because of the rapid temperature changes in this region.

The thermal resistance and capacitance for each lumped element may be calculated from Table II using average values of the properties for the given element. The resistance of the air film at the surfaces may be calculated from

$$q_t = hA\Delta T = \frac{\Delta T}{R_t} \quad (23)$$

The thermal non-dimensionalizing terms T_m, C_{tm} and R_{tm} may be arbitrarily chosen to be respectively the desired temperature drop, the thermal capacitance and the thermal resistance of the second lamination in the floor. The magnitude of the corresponding electrical components V_m, C_{em} and R_{em} may be arbitrarily selected. The remaining

electrical components can then be calculated using equations (21).

The slider "B" is regulated during the test to provide a current flow through the recording ammeter "A" which is proportional to the refrigeration capacity variation for the proposed refrigeration system. The magnitude of the current is varied in successive tests until the desired voltage drop occurs in the required electrical time. The use of equation (21d) then gives the refrigeration capacity required for this transient situation.

THE D.C. ELECTRONIC ANALOG COMPUTER

General purpose analog computers make use of a number of physical media. The predominant realm, however, is the electrical. In general, this type of computer is a compact, versatile engineering tool which can serve as a model of virtually any system encountered by the engineer. The physical elements of this type of computer are arranged in such a manner as to make available a set of operations which is mathematically equivalent to the functional operations of the system under study.

The d.c. electronic analog computer uses electrical components as the analogs of the system under study. The variables are represented by d.c. voltages which vary with time, while time itself is used as the independent variable. Solutions to most problems are obtained through the simple mathematical operations of addition, subtraction and integration of voltages. Problems involving non-linearities are handled by the addition of appropriate non-linear function generators.

Before a problem can be solved it is necessary to interconnect the basic elements of the computer, such as the high gain d.c. amplifiers, precision resistors and capacitors, and coefficient potentiometers, to provide the equivalent mathematical relationships. If the computer installation is small, this setting up of the problem must be done on the computer itself. If the installation is large, the problem is set up on a "prematch" panel which can be wired away from the computer. This panel can then be inserted into the computer whenever it is desired to solve the problem.

The Basic Units:

The d.c. electronic analog computer is comprised of five different types of units 12,13,14. Operational amplifiers and coefficient setting potentiometers are the two most basic units and are common to all electronic analog computers. Additional capability is provided by means of multipliers, resolvers and non-liner function generators. The latter three units are not required for the solution of ordinary linear differential operations, but are necessary for the solution of most other types of problems. A brief description of these units is given in the following paragraphs.

The Operational Amplifier: Operational amplifiers are very high gain d.c. amplifiers having input and feedback networks which enable such mathematical functions as addition, subtraction, integration and differentiation to be performed. Fig. 7 shows an operational amplifier in schematic form. In this figure the d.c. amplifier portion of the operational amplifier is denoted by A, the forward gain. The input impedance is taken to be Z_i and the feedback impedance Z_f. The internal circuitry of the d.c. amplifier is so arranged that there is a 180° phase change between the input and output voltage and this is denoted by the negative sign preceding the gain term A.

If the input voltage is denoted by e_i and the output voltage by e_0, and since under normal conditions the grid input impedance is very high, then

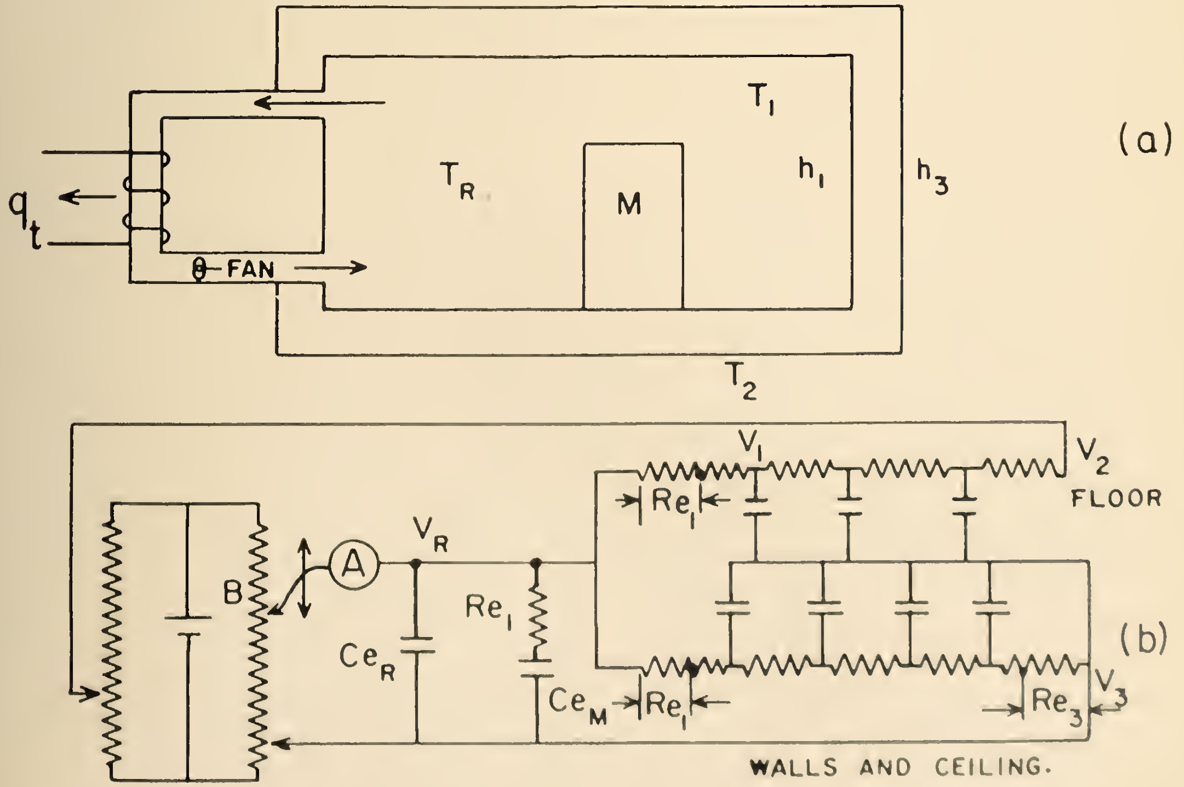
$$e_0 = -\frac{Z_f}{Z_i}\left[\frac{e_i}{1 + 1/A\ (1 + Z_f/Z_i)}\right] \tag{24}$$

Now if A is very large compared unity, which is usually the case, equation (24) approximates to

$$\frac{e_0}{e_i} = -Z_f/Z_i \tag{25}$$

If the input and feedback impedances are purely resistive, $e_0/e_i = -R_f/R_i$. The operational amplifier can serve therefore either as a constant gain amplifier ($R_f > R_i$), an inverter ($R_f = R_i$), an attenuator ($R_f < R_i$), or a variable gain amplifier. Using an operational amplifier as an attenuator is a waste of equipment and consequently

Fig. 6. Transient Heat Flow System (a) and Analog Circuit (b).



the feedback resistance is always chosen to be equal to or greater than the input resistance R_i.

If two or more inputs are connected to an operational amplifier through input resistances as shown in Fig. 8(a) the output voltage, e_0, is proportional to the sum of the input voltages. Thus, for the condition shown

$$e_0 = -[e_1 + 2e_2 + 4e_3 + 10e_4] \quad (26)$$

If the feedback resistance is greater than at least one of the input resistances, the operational amplifier is said to function as a summer-amplifier. If, however, all the resistances are of equal value, the operational amplifier is said to function as a summer-inverter. Operations of this type are usually denoted by block diagram symbols of the type shown in the second column of Fig. 8. Summer-amplifiers are denoted by the block diagram shown in Fig. 8(g) and summer-inverters by the block diagram shown in Fig. 8(h) where the single number 1 denotes sign inversion.

If the feedback impedance is pure capacitance, C_f, and the input impedance pure resistance, R_i, then the output voltage is given by

$$e_0 = \frac{1}{R_iC_f}\int e_i\,dt \quad (27)$$

The operational amplifier now functions as an integrator in which the input voltage is integrated with respect to time. If two or more inputs are connected to an operational amplifier through input resistances as shown schematically in Fig. 8(c), and the feedback impedance is a pure capacitance, the operational amplifier functions as a summer-integrator. The block diagram symbol denoting this operation is shown in Fig. 8(i) where I_0 denotes the initial voltage of the output of the integrator.

An operational amplifier capable of differentiating with respect to time may be obtained by using a pure resistance in the feedback path and a pure capacitance as the input impedance. This type of operation is generally avoided as differentiators have a tendency to amplify noise and, in addition, their inherently good high-frequency response may lead to unwanted high-frequency oscillations. This is not a serious limitation for it is generally possible to use integrators instead of differentiators in problem solving.

Coefficient Potentiometers: Very frequently it is necessary to multiply some voltage by a constant factor which is less than unity. This occurs, for example, when the coefficients of a differential equation are being adjusted. The simplest and most satisfactory way of doing this is to use a simple potentiometer as shown in Fig. 8(d).

In the absence of loading, the output voltage, e_0, is related to the input voltage, e_i, by the expression

$$e_0 = \alpha e_i \quad (28)$$

where α is the mechanical notation, or setting, of the wiper arm. The block diagram notation used to denote attenuation by means of potentiometer settings is shown in Fig. 8(j).

Multipliers: Several types of multipliers are available. The servo-multiplier is the most common and is shown in Fig. 8(e). One of the two voltages to be multiplied, e_1, is applied to one end of a potentiometer and its negative, $-e_1$, to the other end. The servo-mechanism is arranged in such a manner that the potentiometer setting, α, is proportional to e_2, the voltage which is to be multiplied by e_1. The output voltage, e_0, is given, therefore, by

$$e_0 = \alpha e_1 \quad (29)$$

$$= K_1e_1e_2 \quad (30)$$

where K_1 is some proportionality constant.

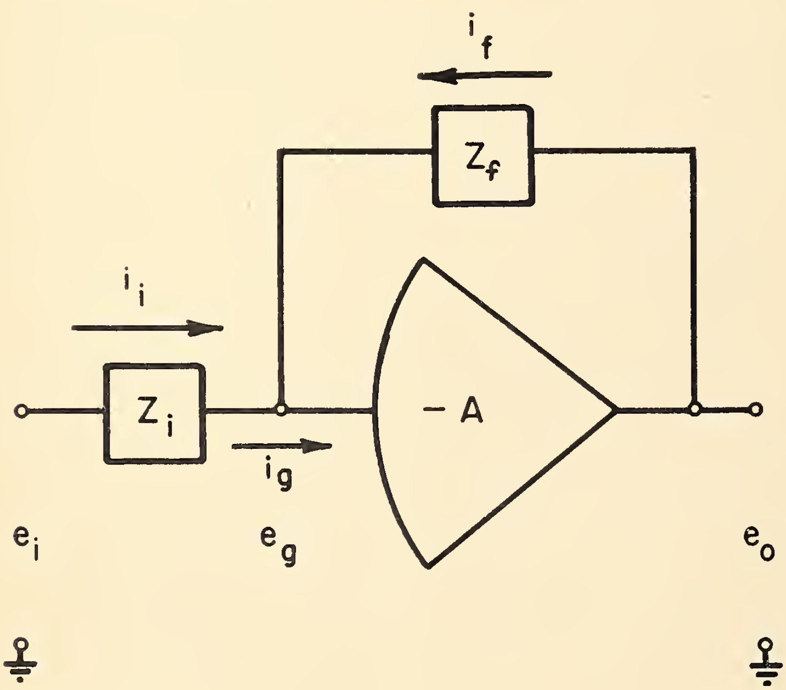
Since α can vary from -1 through 0 to $+1$, the output voltage is proportional to the product e_1e_2 for all combinations of sign. The block diagram symbol used to denote multiplication is shown in Fig. 8(k).

Resolvers: Many applications require the use of trigonometric functions to express angular variations or to perform coordinate transformations. This occurs whenever a description of the same vector quantities is required in terms of two or more different coordinate systems. Several techniques are available for obtaining these transformations. The one which is most common uses specially tapered potentiometers in conjunction with servo-multipliers as shown in Fig. 8(f). The two wipers shown in this figure are separated by 90° and produce the two outputs $e_1\cos\theta$ and $e_1\sin\theta$ where θ is the angular displacement of the servo shaft. Resolvers of this type are usually represented by the symbol shown in Fig. 8(1).

Nonlinear Function Generators: Nonlinear operations cannot be performed with amplifiers and potentiometers alone, but require specially constructed equipment. An almost limitless variety of non-linear function generators can be obtained and it is sufficient to say that these generators are special purpose devices and cannot be treated as generally as the other basic units of the computer.

Initial Condition Sources: In general, n initial conditions are required to specify the solution of a homogeneous differential equation of nth order. In the computer these initial conditions are derived by means of voltages at the output of the n integrators used. This is accomplished by means of an initial voltage source and charging networks which enable the feedback capacitors of the n integrators to be charged to the desired voltage level prior to the start of the computation.

Fig. 7. The Operational Amplifier.



Methods of Solution:

There are basically four methods[14] by which problems can be solved on a general purpose analog comuter. They are:

(i) direct solution; (ii) indirect solution; (iii) implicit function generation and (iv) simulation.

The direct solution method is used for these problems in which the functions to be solved are given functions of the

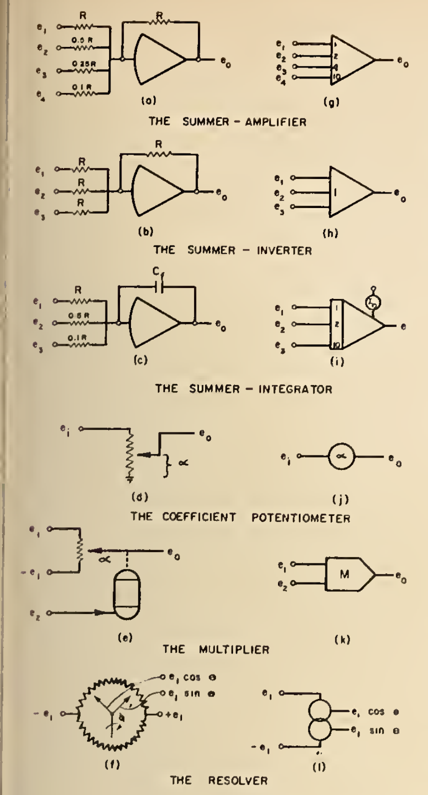


Fig. 8. The Basic Units of the D.C. Electronic Analog Computer.

independent variable t. For example, if

$$x(t) = \int [f_1(t) + f_2(t)]f_3(t)dt \quad (31)$$

the solution for $x(t)$ can be obtained directly from the computer arrangement shown in Fig. 9(a). The functions $f_1(t)$ and $f_2(t)$ are first summed by means of a summer-inverter and then applied to a multiplier to form the product $-[f_1(t) + f_2(t)]f_3(t)$. The result is then integrated to form $x(t)$.

The indirect solution technique is used whenever the solution for a dependent variable involves either derivatives of this variable or other dependent varibles that are being solved for at the same time.

Thus, if $x(t)$ is defined by

$$\ddot{x}(t) + a\dot{x}(t) + bx(t) = f(t) \quad (32)$$

where a and b are constants, $x(t)$ cannot be solved by direct operation of $f(t)$. The procedure used is to assume that the variable $x(t)$ and all of its derivatives with the exception of the highest are available within the computer. An expression is then obtained for the highest derivative as follows:

$$\ddot{x}(t) = f(t) - a\dot{x}(t) - bx(t) \quad (33)$$

The mechanization of this equation is given in Fig. 9(b). The arrangement is of such a form that there is no direct measure of $\ddot{x}(t)$, although $-a\dot{x}(t)$ and $-bx(t)$ may be measured directly. If it is also necessary to monitor $\ddot{x}(t)$ equation (33) must be rewritten in the form

$$-\ddot{x}(t) = -f(t) + a\dot{x}(t) + bx(t) \quad (34)$$

and mechanized as shown in Fig. 9(c). This involves the expenditure of an additional amplifier compared to the arrangement shown in Fig. 9(b).

The implicit solution technique involves the solution of an implied equation rather than the given equation. Thus, if the given equation is

$$x(t) = a(b + t)^4 \quad (35)$$

the solution for $x(t)$ can be obtained by taking the natural logarithm of both sides and differentiating with respect to t. The result is

$$\dot{x}(t) = \frac{4}{b + t}x(t) \quad (36)$$

which can be mechanized as shown in Fig. 9(d).

Simulation forms the most important and wide-spread of the analog computer applications. It involves the construction of a physical model of the system being studied on the analog computer. The computer components are interconnected in such a manner that there is a direct correspondence between each element of the system and each element of the model. The computer variables will behave therefore in the same manner as the variables of the system.

There are two main advantages to this technique: (i) A mathematical model of the system being investigated is not required. This is particularly useful when dealing with complex and nonlinear systems which defy any reasonable mathematical definition. (ii) The effects due to changes in the characteristics of the system's elements and due to changes in external environment can be readily investigated.

Scale Factors:

Scale factors are constants which relate the computer variables to the variables of the problem being solved. The necessity for their existence arises from the fact that the behaviour of the variables of the computer, which is itself a physical system, must be directly related to the variables of the physical system being studied. The independent variable of the electronic analog computer is time and under normal conditions the computer can solve only those problems which require solution times somewhere between 15 seconds at a minimum and four to five minutes at a maximum. To handle problems outside this range it is necessary to establish a relationship between computer time τ and problem time t.

At present, there are two methods of time scaling. They involve somewhat different procedures and thought processes, but produce exactly the same

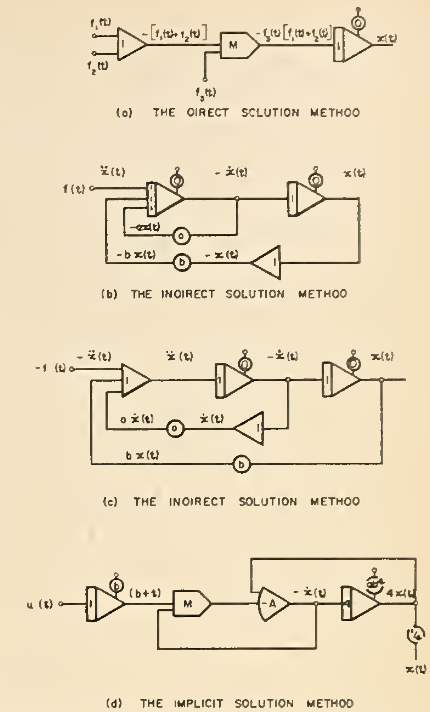


Fig. 9. Typical D.C. Electronic Analog Computer Wiring Diagrams.

results. The method used in this paper consists of changing the time associated with the physical system by letting

$$t = \frac{1}{r}\tau \quad (37)$$

where τ = computer time, usually in seconds
t = real time of the problem in appropriate units
r = time scale factor.

Applying this technique to equation (32) gives

$$r^2\ddot{x}_c(\tau) + ra\dot{x}_c(\tau) + bx(\tau) = f_c(\tau) \quad (38)$$

where
$$x_c(\tau) = x(\tau/r)$$
$$f_c(\tau) = f(\tau/r) \quad (39)$$

Time scaling the physical system in the above manner also changes the values of the initial conditions and maximum values of the derivatives by the time scale factor. Thus, if the initial conditions at $t = 0$ are

$$x(0) = I_1 \quad \text{and} \quad \dot{x}(0) = I_2,$$

the values following time scaling become

$$x_c(0) = I_1 \quad \text{and} \quad \dot{x}_c(0) = I_2/r.$$

In addition, if the assumed maximum values for the derivatives are

$$x_{max}(t) = L_1,$$

$$\dot{x}_{max}(t) = L_2$$

$$\text{and} \quad \ddot{x}_{max}(t) = L_3,$$

the values following time scaling are

$$x_{c\max}(\tau) = L_1,$$
$$x_{c\max}(\tau) = L_2/r$$
and $$x_{c\max}(\tau) = L_3/r^2.$$

Magnitude scale factors are required because the dependent variable in a computer is a voltage which is usually limited to the -100 to $+100$ volt range. The analogous problem variable usually has different units, say feet, and is restricted to a different range. Even if the problem variable was a voltage, it would be restricted most likely to a different range and there still would be a need for a magnitude scale factor.

There are several ways of relating computer voltage to the dependent variables of the physical system. The method which is used in this paper is that of scaling with dimensional units. This consists of relating computer voltage and physical variables by means of the expression

$$v_c = Kx \tag{40}$$

where v_c = computer voltage

x = physical variable in appropriate units

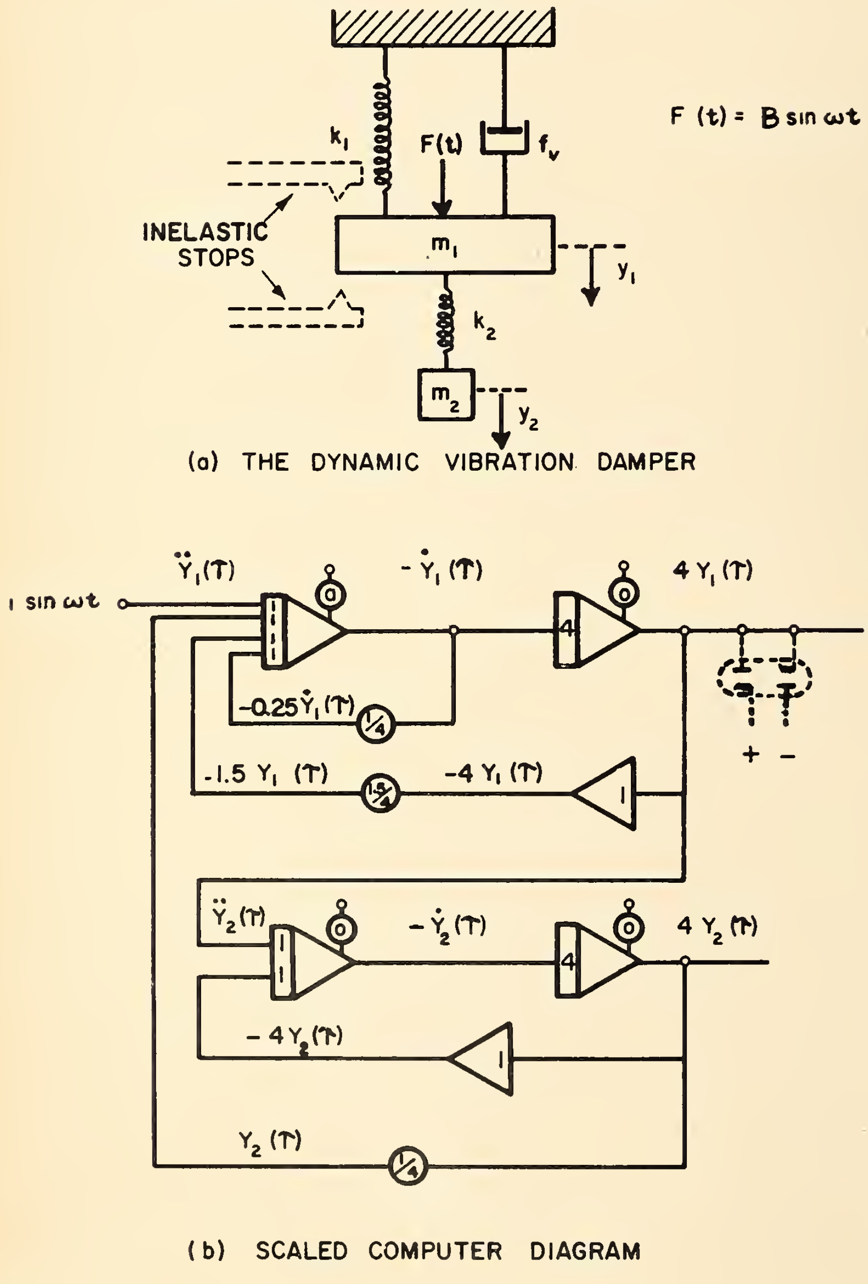
K = magnitude scale factor.

Thus, since the assumed maximum values of position, velocity and acceleration for the system defined by equation (32) are L_1, L_2/r and L_3/r^2 following time scaling, the appropriate magnitudes scales for a computer working between $+100$ and -100 volts would be

$$K_1 = \frac{100}{L_1},\quad K_2 = \frac{100}{L_2/r} \text{ and } K_3 = \frac{100}{L_3/r^2}.$$

Selection of magnitude factors, as seen from the preceding paragraphs, depends upon prior knowledge of expected maxima of the physical variables. Usually these maxima are impossible to calculate and must be estimated. This is accomplished from a knowledge of the physical system and even if these estimates are proved incorrect by future computer studies no great harm is done since the magnitude scale factors can be changed readily.

Fig. 10. Dynamic Vibration Damper—Example.



Types of Problems That Can Be Solved:

There are basically two types of problems that can be solved with general purpose analog computers. They are the solution of mathematical models and simulation. The types of mathematical models that can be handled are ordinary linear differential equations, ordinary differential equations with variable coefficients, ordinary non-linear differential equations, partial differential equations, integral equations and matrices. Almost any type of problem can be handled by simulation, which is readily apparent from the discussion of the preceding section.

A few specific examples are treated in the following sections of this paper as an illustration of the techniques outlined. This illustration is very far from complete and the interested reader would find it highly profitable to pursue this topic further by referring to some of the excellent publications listed in the references to this paper.

The Dynamic Vibration Absorber: An illustrative example[13] of a problem which can be handled by the indirect solution technique is that of the dynamic vibration absorber shown in Fig. 10(a) in which the small mass m_2 is used to reduce or to eliminate the vibrations of the large mass m_1 If $y_1(t)$ represents the displacement in the y direction of mass m_1 and $y_2(t)$ represents the displacement of mass m_2 in the same direction, then the equations of motion of m_1 and m_2 are

$$m_1\ddot{y}_1(t) + f_v\dot{y}_1(t) + k_1y_1(t) + k_2[y_1(t) - y_2(t)] = B\sin\omega t \tag{41}$$

and

$$m_2\ddot{y}_2(t) + k_2[y_2(t) - y_1(t)] = 0 \tag{42}$$

Under normal circumstances m_1, k_1, f_v and B are of known and constant value and the design problem is that of choosing m_2 and k_2. In particular, let it be assumed that the numerical values of the constants are $m_1 = 2$ slugs, $k_1 = 1$ lb./ft., $f_v = 0.5$ lb.-sec./ft. and $B = 2$ lbs. In addition, let it be assumed also that it is desired to determine the oscillation amplitude and phase of m_1 as a function of the driving frequency in the range $\omega = 0.5$ to $\omega = 5$ rad./sec. for several combinations of m_2 and k_2, the first of which is $m_2 = 0.5$ slug and $k_2 = 2$ lb./ft.

By substituting the values of the constants into equations (41) and (42) and by solving for the highest derivatives of y_1 and y_2 one obtains

$$\ddot{y}_1(t) = \sin \omega t - 0.25\dot{y}_1(t) - 1.5y_1(t) + y_2(t) \quad (43)$$

$$\ddot{y}_2(t) = -4y_2(t) + 4y_1(t) \quad (44)$$

The range of frequencies for which the system performance is to be investigated is such that solution times of about three minutes would be required at a maximum and 20 seconds at a minimum. This corresponds with the computer solution times normally used and consequently the time scale factor may be taken to be unity. This means that computer time τ is exactly equivalent to the problem time t and equations (43) and (44) can be expressed in computer time by merely substituting τ for t.

Magnitude scaling could follow the procedure outlined previously in which $y_1(t)$, $y_2(t)$ and their first and second derivatives would be scaled according to the estimated maximum value of each quantity. This would make the discussion of the mechanization of equations (43) and (44) somewhat complicated and for convenience a single magnitude scale factor will be chosen for all quantities based on assumed maximum values for $y_1(t)$ and $y_2(t)$. Thus, if it is assumed that both $y_1(t)$ and $y_2(t)$ will vary between the limits of $\pm$ 3 ft., then a magnitude scale factor which would ensure that the first and second derivatives of $y_1(t)$ and $y_2(t)$ would not exceed those limits corresponding to $\pm$ 100 volts would be K = 10 v./ft.

The scaled equivalents of equations (43) and (44) are therefore

$$\ddot{Y}_1(\tau) = 10 \sin \omega\tau - 0.25\dot{Y}_1(\tau) - 1.5Y_1(\tau) + Y_2(\tau) \quad (45)$$

$$\ddot{Y}_2(\tau) = -4Y_2(\tau) + 4Y_1(\tau) \quad (46)$$

where for convenience $Y_1(\tau)$ and $Y_2(\tau)$ are taken to be scaled equivalents of $y_1(t)$ and $y_2(t)$.

If it is assumed that the initial conditions are all zero, then the computer set-up for the solution of this problem in terms of computer variables is that shown in Fig. 10(b).

The Dynamic Vibration Absorber with Inelastic Stops: It is well known that the vibration absorber shown in Fig. 10(a) can be analyzed without the use of an analog computer. The main advantage of using an analog computer is that the oscillation of m_1 can be explored quickly and easily for a large number of $m_2 - k_2$ combinations.

Another advantage of the analog computer is the fact that a system dynamically similar to that shown in Fig. 10(a), but restrained by inelastic stops, can be handled with very little additional complexity. Thus, if the motion of m_1 is restricted by inelastic stops as shown by the dashed lines in Fig. 10(a), the only modification that must be made to the analog computer set-up is the addition of a diode limiter which limits the maximum excursion of $4Y_1(\tau)$ to the appropriate voltage range. This modification to the computer set-up is indicated by dashed lines in Fig. 10(b).

Without the use of an analog computer, the motion of m_1 would have to be determined by numerical methods.

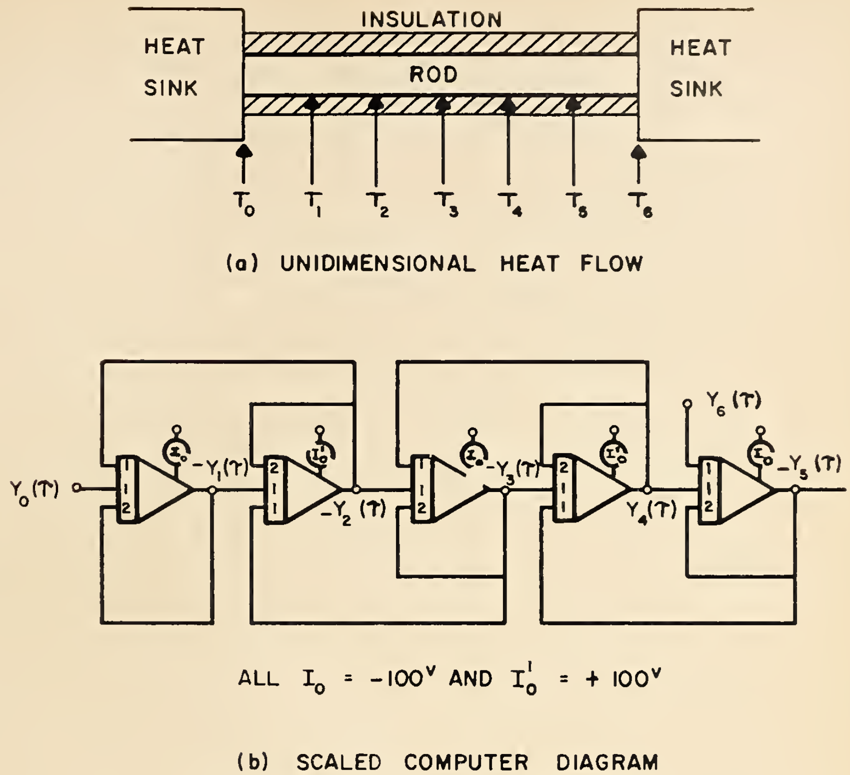


Fig. 11. Unidimensional Heat Flow—Example.

Unidimensional Heat Flow: Many problems which arise in engineering and physics involve partial differential equations that are subjected to certain boundary values and initial conditions. In general, these problems can be solved either by analytical or numerical methods, but the amount of labour involved is usually excessive. However, approximate solutions of good quantitative accuracy can be obtained with an analog computer. An illustrative example is the problem of transient unidimensional heat flow.

The equation describing heat flow in this situation is simply:

$$\frac{\partial T(x,t)}{\partial t} = \frac{k_t}{c_t\rho}\frac{\partial^2 T(x,t)}{\partial x^2} \quad (47)$$

A solution to this equation will be subjected to two boundary values and one initial condition. This equation also involves the two independent variables time and distance. An exact solution on a general purpose d.c. electronic analog computer is not feasible because time is the only independent variable available. To carry out a solution on this type of computer it is necessary to transform the partial differential equation into a system of ordinary differential equations by finite difference techniques. In this way the solution will express the temperature as a function of time at finite increments of distance.

As a specific example of this technique, consider an insulated rod of length 6 ft. made of a material for which $k_t/C_t\rho$ = 1.0. Suppose that both ends of the rod are held at a temperature of 0°F and that the temperature of the rod was initially 200°F. If it is desired to determine the temperature distribution along the rod as a function of time, then the first step in the solution of the problem is to divide the rod into segments of equal length, say 1 ft. The next step is to write a system of first order ordinary differential equations describing the temperature at each point in terms of its own coordinates and those of its neighbouring points. Thus, for the condition shown in Fig. 11(a) the system of equations is

$$\frac{dT}{dt} = \frac{k_t}{c_t\rho}\left[\frac{T_{n+1} - 2T_n + T_{n-1}}{\Delta x^2}\right] \quad (48)$$

for n = 1 to n = 5 inclusive.

This finite difference equation contains two more unknowns than there are equations. This additional information is supplied by the two boundary conditions $T_0 = T_6 = 0$°F. Equation (48)

can now be expanded and mechanized as shown in Fig. 11(b).

The temperature of the rod will vary from a maximum of 200°F down to a minimum of 0°F. Since differentiation will be avoided, and there is no need for amplification, a magnitude scale factor of $k = 1/2$ volt/°F may be chosen. A solution time of about one hour appears to be a reasonable estimate and a time scale factor of $r = 60$ sec./hr. may be chosen. Initial condition values of $100V = 200$°F must be applied throughout.

The block diagram of the computer set-up for the solution of this problem is shown in Fig. 11(b). One summer integrator is used for each lattice point and this is generally the case. However, due to the symmetry of this particular problem lattice points 1 and 2 must be at the same temperature as lattice points 4 and 5. Consequently, summer integrators 4 and 5 are redundant.

Unidimensional heat flow problems are usually more complicated than that just analyzed. Thus, for example, the boundary conditions may vary with time. For this condition the computer set-up must be modified to accommodate these by programming T_0 and T_6 as functions of time.

In problems of this type the accuracy of the solution is a function of the fineness of the lattice. Considerable accuracy can be obtained using a very fine lattice, but this involves the expenditure of additional amplifiers. The main advantages of an analog computer in such problems is that initial and boundary conditions can be easily investigated over wide ranges and the effects of non-linearity studied in detail.

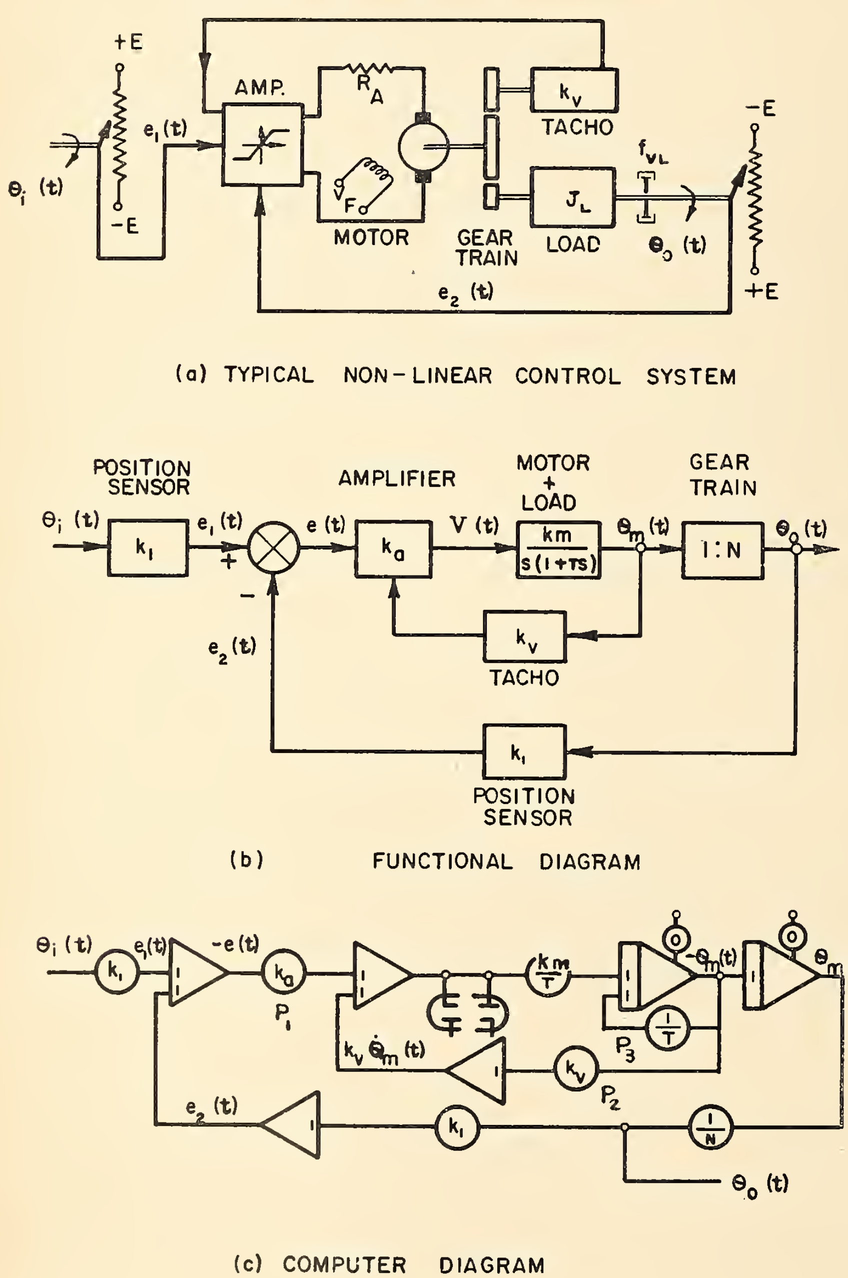
Simulation of Feedback Control Systems: Simulation is used whenever the problem which is to be investigated is either too complex to be expressed mathematically, or requires information concerning the inner workings of the system under study. In general, simulation is similar to the techniques used to solve problems which are defined by mathematical models. It requires a model of the system to be investigated and this is provided in the form of a functional block diagram which details all the information required with the exception of the initial conditions. Proper time and magnitude scale factors must be selected and incorporated into the computer set-up. Ignoring scaling the resulting computer diagram is exactly equivalent to the system block diagram.

The concepts involved in analog computer simulation may be best illustrated by a detailed study of the feedback control system shown in Fig. 12. The system shown is of standard form. It consists of a potentiometer bridge which measures the difference between the rotations of the input and output shafts, a servo-amplifier, a direct current shunt-wound motor with constant field excitation, a gear train which couples the motor to the load, and a tacho generator which provides velocity feedback stabilization. As it stands, the system could be investigated using standard techniques of analysis and synthesis. However, if it is assumed that the servo-amplifier saturates at a maximum output of $\pm V_a$ volts, computer techniques must be used.

The problem facing the design engineer is that of establishing the amplifier gain k_a and the velocity feedback signal coefficient k_v which will enable the system to meet certain design specifications based on a sinusoidal input to the control system. The first step in the solution is to translate the system shown in Fig. 12(a) into a functional diagram as shown in Fig. 12(b). The latter details all the information which is required to solve the problem.

The second step in the solution is to establish a computer model of the system from the functional diagram of Fig. 12(b). This is shown in Fig. 12(c) where scaling has been ignored to retain simplicity. To a large extent this figure is self-explanatory. The input and output position sensors have been replaced by a summer-amplifier. The servo-amplifier has been replaced by a variable gain summer-amplifier followed by diode limiters. The load inertia J_L and viscous friction coefficient f_{vL} have been combined with the motor armature inertia J_a and viscous friction coefficient f_{va} and have been replaced by the two integrators shown. The gear train has been replaced by a single coefficient potentiometer.

Fig. 12. Non-Linear Control System—Example.



To establish satisfactory values of k_a and k_v it is merely necessary to vary the settings of the coefficient potentiometers P_1 and P_2 and to observe the corresponding system response to the driving function $\theta_i(t)$. Another advantage of using the analog computer is that if there is some doubt as to the actual values of some of the system constants, it is relatively easy to incorporate this uncertainty into the computer set-up. For example, if the time constant of the motor is not known accurately the effect of this uncertainty may be investigated by merely changing the settings of coefficient potentiometer P_3.

COMPUTER COMPARISONS

Accuracy: In general analog computers are limited to problems which can be satisfied by answers having three significant figures. This is not a serious limitation for in many situations the so-called known data may be in error by 25% or more. Exclusive of recording errors, analog computer accuracy is almost entirely dependent on the quality of the components used. At present it is usually impossible to calculate accurately the errors associated with the solution of practical problems. Estimates based on comparisons with exact solutions for simple problems show that for conducting sheet analogs the limit of accuracy is about 2%. The accuracy of resistance-capacitance networks is about 2% also, but with care it can be improved to better than 1%. The accuracy of the d.c. electronic analog computer is difficult to estimate. The error in each individual linear operation can be as low as 0.02%, but the overall error, even in the finest of installations, is still of the order of 1% to 2%.

Flexibility: Conducting sheet analogs and resistance-capitance networks are easy to program. The former requires only that the conducting sheet material be cut to a shape proportional to the cross section of the system being studied. The latter requires the interconnection of a number of resistors and capacitors to form a network representing the original system. With the d.c. electronic computer problem set-up frequently occupies a major portion of the time devoted to the investigation. To minimize the effort required, the internal connections are usually brought out to a centrally located patch bay. In large installations the patch bays are equipped with patch panels which can be suitably interconnected away from the computer thus leaving the computer free for the solution of problems already set up on other patch panels.

Ease of Maintenance: Special purpose analog computers of the type discussed in this paper require little or no maintenance. D.C. electronic analog computers require a reasonable amount of preventive maintenance. The amount required increases with an increase in the size of the installation, but it seldom exceeds the part time attention of one technician.

CONCLUSIONS

Two basic types of analog computers have been discussed and a detailed treatment has been given of a number of their specific applications. These computers have also been compared as far as accuracy, flexibility and maintenance are concerned. It is concluded from this discussion that conducting sheet analogs and resistance-capacitance network analogs are most suitable for use in the solution of field problems. The former is limited to the solution of the Laplace and the Poisson equations in one or two dimensions. The latter complements the former in that it may also be used to solve the conduction equation. The d.c. electronic analog computer can solve almost any problem which can be expressed by either a mathematical or physical model. However, it finds its widest application in the solution of ordinary linear differential equations, ordinary differential equations with variable coefficients, ordinary non-linear differential equations and in simulations. It is one of the most useful of engineering tools.

ACKNOWLEDGEMENTS

The authors would like to acknowledge the support for their work from the Saskatchewan Research Council; the National Research Council under grant No. A-1080 and the Defence Research Board under grant No. 2804-05.

Nomenclature

k = generalized conductivity, spring constant.
C = capacitance.
R = resistance.
A = area, operational amplifier forward gain.
ϕ = generalized potential, Torsional shear stress potential, velocity potential.
t = time.
i = electric current.
V = electrical potential.
ρ = density.
C_p = specific heat at constant pressure.
h = heat transfer coefficient.
q = flux.
T = temperature.
D = diffusion coefficient
m = mass.
K = compressibility, magnitude scale factor.
f_p = porosity.
P = pressure, potentiometer.
P_p = partial pressure.
τ = stress (force), computer time following time scaling
θ = angular displacement
ω = angular frequency radians/unit time.
G = torsional rigidity, electrical conductance.
J = moment of inertia or initial voltage.
$u(t)$ = unit step function.
ψ = Transformed potential defined by equations (5) and (6).
u = strain (length).
E = modulus of elasticity.
L = length.
p = hydraulic permeability of a porous medium.
ν = kinematic viscosity.
Z = impedance.
e = voltage.
α = potentiometer setting.
$\boldsymbol{r}$ = time scale factor.
f_v = viscous damping coefficient.

Subscripts

b = boundary condition.
e = electrical.
f = feedback.
i = input or general index.
o = output or as specified.
t = thermal.

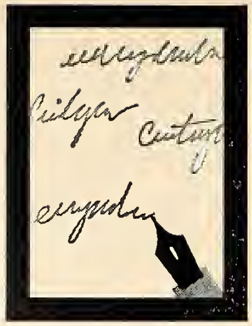
Superscripts

$'$ = per unit length.
$''$ = per unit area.
$'''$ = per unit volume.
$\cdot$ = per unit time.
$-$ = average.

Bibliography

1. W. J. Karplus, **Analog Simulation**, McGraw-Hill Book Company, Inc., (1958).
2. V. Paschkis, Combined Geometric and Network Analog Computer Solution for Transient Heat Flow, Trans. A.S.M.E., Part C, May, 1959, pp. 144-149.
3. D. Rosenthal, R. D. Mackey, and P. R. Dahl, Discussion Proc. Soc. Exp't'l Stress Anal., Vol. XI, No. 1, pp. 27-30.
4. E. O. Gilbert and E. G. Gilbert, Capacitively Coupled Field Mapper, Trans. A.I.E.E., 1953, pp. 345-351.
5. N. S. Waner and W. W. Soroka, Stress Concentrations for Structural Angles in Torsion by the Conducting Sheet Analog, Proc. Soc. Exp't'l Stress Analysis, Vol. XI, 1953, pp. 19-26.
6. C. F. Kayan, An Electrical Geometrical Analog for Complex Heat Flow, Trans. A.S.M.E. Vol. 67, 1945, pp. 713-718.
7. C. F. Kayan, Heat Transfer Temperature Patterns of a Multicomponent Structure by Comparative Methods, Trans. A.S.M.E. Vol. 71, 1949, pp. 9-16.
8. T. J. Higgins, Analogic Experimental Methods in Stress Analysis as Exemplified by Saint-Venant's Torsion Problem, Proc. Soc. Exp't'l Stress Analysis, Vol. II, 1945, pp. 17-27.
9. V. Paschkis, and H. D. Baker, A Method for Determining Unsteady State Heat Transfer by Means of an Electrical Analog, Trans. A.S.M.E., Vol. 64, 1942, pp. 105-112.
10. V. Paschkis and M. P. Heisler, The Accuracy of Measurements in Lumped R-C Cable Circuits as Used in the Study of Transient Heat Flow, Trans. A.I.E.E., Vol. 63, 1944, pp. 165-171.
11. V. Paschkis, Comparison of Long Time and Short Time Analog Computers, Trans. A.I.E.E. Vol. 68, 1949, pp. 70-73.
12. E. M. Grabbe, **Handbook of Automation, Computation and Control**, Vol. 2, John Wiley and Sons (1959).
13. G. A. Korn and T. M. Korn, **Electronic Analog Computers**, McGraw-Hill, (1952)
14. A. Jackson, **Analog Computation**, McGraw-Hill, (1960)
15. R. N. Lloyd and V. J. Bakanowski, Electronic Computation in the Chemical Industry, Engineering Journal of the E.I.C., Vol. 43, no. 12, December, 1960
16. H. M. Paynter, Palimpsest on the Electronic Analog Art, George A. Philbrick Research (1955)

Abstracts



Papers to be presented at the 1962 EIC Annual General Meeting

Following are the abstracts received by press time. Abstracts of other papers to be presented at the 1962 Annual General Meeting will appear in the May issue of the Engineering Journal.

AGM Paper #21

The Effect of Slimes on Open Channel Transport of Fluidized Solids

Ralph W. Ansley, A.M.E.I.C.
Assistant Professor of Civil Engineering, University of Alberta

This paper discusses some aspects of research carried out on high density fluidized solids transport in open channel flow at University of Alberta.

Commercial operators have noticed that flume transport of tailings is facilitated by the addition of slimes or sludges to the tailings slurry. A laboratory programme is currently underway to evaluate the effect of blending of slimes and tailings. Results to date show a substantial increase in percentage tailings transported for a given hydraulic gradient at a constant discharge due to the addition of slimes. The data and a discussion of same are presented herein.

AGM Paper #16

Design Concepts of Brazeau Development including River and Hydrology Studies

K. G. Brittain, M.E.I.C.,
Design Engineer, Montreal Engineering Company, Montreal
J. L. Reid, M.E.I.C.,
Supervisor, Hydro-Electric Development, Department Water Resources, Edmonton, Alberta

The search for power and storage in Alberta has resulted in an agreement between the Province of Alberta and Calgary Power Ltd. to build the Brazeau Storage Development. The initial stage of the dam is now completed and stored water is being released to increase the winter discharge of the North Saskatchewan River. Calgary Power is proceeding with development of power for the fall of 1964. The paper describes the background and events leading up to this combined effort between Government and Public Utility.

The Project is being developed to produce peak capacity and peak energy and will complement other sources of power in the Province. Provision has been made to permit its future integration with other prospective sites on the Brazeau River. These future sites are outlined in the paper. As a result of the investigations it is expected that the Brazeau river will play an important part in the future power supply of the Province as well as providing increased winter discharge in the North Saskatchewan.

The hydrological investigations are discussed. This includes the methods used to estimate run-off for power output and floods. Reservoir operation rule curves are outlined with a discussion of the rule curves in relation to the floods and spillway facilities.

AGM Paper #12

The Engineering Operation of Large Pipe Lines

C. D. Bailey, M.E.I.C.,
Chief Engineer, Trans Mountain Oil Pipe Line Company, Vancouver, B.C.

Principles and procedures for the safe and economic operation of large high pressure pipe lines have been developed in Canada and other countries. These are significant and it is hoped that their presentation will be of benefit to safety and economy in the organization of efficient pipe line systems. The paper deals with:

a) The effect of terrain on the selection of pipe line route and the effect of right-of-way on regional drainage systems, including methods to be adopted to secure stability. Submarine crossings of rivers and tidal waterways.
b) Safeguards and forward planning for future transmission requirements by initial diameter. Economic diameters of pipe versus capacity.
c) High test line pipe—advantages and dangers. Welding of connections. Basic rules for testing and consideration of testing to yield. Repair of hot lines after entry into service.
d) Surge considerations in liquid lines of telescopic design. Dampening effects of long slender lines. Effects of surge on protective pressure shutdown settings.
e) Establishment of and continuing revision to pumping pressure with change in gradients in order to contain working pressures of pipe lines within allowable pressure at optimum throughputs. Pre-set pressure allowances for protective alarms and shutdown equipment.
f) Cold weather operations. Design of fittings, tanks, piping and apparatus for extremely low temperatures. Operating techniques and principles.
g) Contemporary developments for increase in efficiency and reduction of operating costs. Continuous metering. Automatic run measurement and determination of batch elements. Remote and centralized control. Interface phasing in looped pipe lines.

AGM Paper #45

Bottom Outlets Under High Head

J. P. Bertrand,
Machine Testing Department, Sogreah, Grenoble, France
E. Pariset, M.E.I.C., *Vice-President, LaSalle Hydraulic Laboratory Limited, Montreal*

The authors describe the different duties of bottom outlet gates under high heads and the corresponding problems met in their design. They show that the surrounding structures and even the discharge area form a part of the whole design.

Special consideration is given to cavitation problems

inasmuch as they appear in the study under discussion. It is explained how the problems arise, how they develop, how they can be investigated with models and, finally, how they can be solved.

AGM Paper #19

The Isolation of the Buildings in the Place Ville Marie Development from Railroad-Induced Vibrations

J. E. Brett, M.E.I.C.,
Brett & Ouellette, Consulting Engineers, Montreal, Que.

This paper describes the design and installation methods used to counteract the effects of railroad-induced vibrations upon the various components of the project, including the Royal Bank of Canada Building. The paper also summarizes the techniques and results of the extensive field studies carried out to delineate the noise and vibration environment to which the structures will be exposed.

AGM Paper #9

The Structural Design of the Place Ville Marie Project

J. E. Brett, M.E.I.C.,
Brett & Ouellette, Consulting Engineers
R. P. Ouellette, M.E.I.C.,
Brett & Ouellette, Consulting Engineers
R. R. Nicolet, A.M.E.I.C.,
Project Manager, Brett & Ouellette, Consulting Engineers, Montreal

This paper describes the main features of the structural analysis and design carried out for the Place Ville Marie Project in downtown Montreal. Special emphasis is given to the design of the Royal Bank of Canada Building. The architectural features of this building, the Cruciform shape and a height in excess of six hundred feet, necessitated the use of unusually complex methods of investigation. The paper describes the extensive use made of an IBM 704 computer to solve the complex of problems arising from various combinations of live and dead load, wind and earthquake loads and from stability considerations. Extensive application of the composite method of construction was made possible by the layout of the framing. The main features of the structural systems of the parking floors below street level, the Quadrant Buildings and the Cathcart Building are outlined. The presence of the Canadian National Railways tracks necessitated careful insulation of the various buildings against vibrations. This particular aspect is discussed in another paper.

AGM Paper #24

Magnetic Inverters. A Review of Switching Processes and Some New Developments in Self-Locking Circuits

C. H. R. Campling, M.E.I.C.,
Associate Professor, Department of Electrical Engineering, Queen's University, Kingston, Ontario
J. A. Bennett, A.M.E.I.C.,
Lecturer, Dept. of Electrical Engineering, Queen's University, Kingston, Ontario
D. H. O'Hara, A.M.E.I.C.,
Junior Research Officer, Radio and Electrical Engineering Division, National Research Council, Ottawa, Ontario

Switching in single-phase inverters and transient locking phenomena in polyphase inverters are discussed. The class of inverters with which the paper deals includes those in which the operating frequency and (for polyphase inverters) the electrical angles between phases are determined by the characteristics of the inverter transformers. Polyphase units of this type are known as self-locking inverters.

Two circuit arrangements are presented which permit the generation of pure rectangular voltage waveforms at arbitrary voltage levels with self-locking inverters. In addition a simple method is demonstrated for generating output waveforms which are stepped approximations to sinusoids.

AGM Paper #36

Settlement Studies on the Mt. Sinai Hospital, Toronto

C. B. Crawford, M.E.I.C. and *K. N. Burn*, M.E.I.C.,
Soil Mechanics Section, Division of Building Research, National Research Council, Ottawa, Canada

Settlement measurements on a large structure founded on a reinforced concrete mat over glacial till subsoil are reported and compared with estimates derived from laboratory testing. The modulus of elasticity of the subsoil derived from full-scale field measurements is compared with laboratory values. The performance of this type of foundation is discussed.

AGM Paper #48

The Design and Construction of The Shawinigan Water and Power Company's 345 KV Transmission Line Using Guyed and Rigid Structures

V. F. Crowley,
Manager, Transmission Division, The Shawinigan Engineering Company Limited
S. T. Rudkin, M.E.I.C.,
Senior Design Engineer, The Shawinigan Engineering Company Limited

The Shawinigan Water and Power Company's 135-mile 345 KV transmission line from Isle Maligne to Quebec is the first extra high voltage line on this continent to use guyed type towers for the major portion of its length. This paper provides a description of the line background and the terrain traversed, a review of the studies leading to the decision to use a combination of guyed and rigid structures, a discussion of the mechanical and electrical design features of the line, a description of construction methods employed, and a summary of the advantages of the guyed portal over the rigid type transmission line tower.

AGM Paper #64

The Effect of Exterior Building Construction Upon the Cost of Heating and Air Conditioning Systems

G. H. Green, M.E.I.C.,
Mechanical Engineering Department, University of Saskatchewan, Saskatoon, Canada

The paper is directed mainly to architects, managers and owners of buildings to show them how the selection of exterior wall construction affects the costs of heating and air conditioning systems.

Tables are presented to show what various types of exterior construction contribute towards the initial cost of systems. In particular, the effect of glass is studied and it is concluded that glass area must be carefully used in a building since glass area can contribute from $1.50 to $7.50 per square foot of window towards the cost of the air conditioning system.

AGM Paper #67

Design and Construction Aspects of the Beechwood Third Unit

G. E. Gunther, M.E.I.C.,
Mechanical Engineer, Design and Construction Division, New Brunswick Electric Power Commission

The New Brunswick Electric Power Commission has recently put into operation the third and final unit at the Beechwood Generating Station on the Saint John River. This Unit is a 230" diameter Kaplan turbine rated at 55,500 H.P. at a net head of 57 feet and is somewhat larger than the existing two units. The size and type of turbine was determined after a comprehensive analysis of the economics of Kaplan and fixed blade propeller turbines in sizes carrying from 45,000 H.P. upward. The study, which was greatly simplified by the use of a digital computer, showed a slight economic advantage in favour of a large fixed blade propeller machine. However the better operation of the Kaplan turbine in the N.B.E.P.C. system dictated the final choice.

The governor for the new turbine is of the electro-hydraulic type similar to those on units 1 and 2. The generator is a vertical umbrella type rated at 45,000 KVA at 0.9 power factor. A second 138 KV single circuit transmission line between Beechwood and Fredericton was constructed to handle the greater output from the station

Model testing carried out by the turbine manufacturer showed very low efficiencies from the combination of the new turbine and the existing draft tube. Investigations showed that the problem was caused by an incompatability between turbine and draft tube which manifested itself as a separation at the elbow of the tube. Rather extensive modifications to the model draft tube were carried out which returned efficiencies to a point well above the guaranteed values. These changes have been made on the prototype tube using steel plates and plain and epoxy concrete.

AGM Paper #23

Electronics and the Future

W. L. Haney
National Research Council,
Radio and Electrical Engineering Division,
Ottawa, Canada

Research now going on in scientific and engineering laboratories may indicate future engineering development and application. Some of the electronic research now underway is reviewed, and an attempt is made to estimate the future significance of this work. Among the subjects considered are plasma physics, satellite communication, optical masers, and bionics.

AGM Paper #73

Unusual Problems in Development of Caland Mining Operation at Steep Rock Lake

E. W. Whitman
Superintendent, Open Pit Mining,
Caland Ore Company Limited
S. A. Reipas
Chief Mining Engineer, Caland Ore Company Limited
R. M. Hardy, M.E.I.C.,
Soil Consultant

The Caland iron ore mining development in the Falls Bay area of Steep Rock Lake has involved an investment of close to $60 million over a ten-year period. Development work commenced in 1954 and the first ore shipments were made in 1960. By 1969 production is planned at 3 million tons per annum. First production will be from large open pits, but eventually it is expected to come from underground operations. The orebody lies below the bottom of the lake and the dredging of some 162 million cubic yards of clay, silt and gravel was required to expose the ore. The paper deals with several unusual problems encountered in the development of the property including the determination of safe dredging slopes to a maximum height of 400 feet in the lake bottom soil, safe drawdown rates for the dredging program, experience with the construction of dams on the lake bottom silts and clays, and the handling of open pit ore through underground hoisting facilities.

AGM Paper #31

Compensated Dynamic Braking of Three-Phase Wound-Rotor Induction Motors

G. Hausen,
Design Engineer, Canadian Controllers Ltd.,
Toronto, Ontario

To meet certain load conditions it is necessary that drive motors produce brake torques. If the drive motor is an induction motor this can be accomplished by exciting its stator winding with direct current and thereby operating the motor as an alternator.

The inherent problems of such a control scheme are the danger of run-away conditions due to under-excitation of the stator and the danger of motor overheating caused by over-excitation. Both problems are eliminated in the compensated dynamic braking system, which employs feed-back control methods to adjust the DC-excitation of the induction motor automatically as a function of existing load conditions. Performance and design of compensated dynamic braking control systems are discussed in this paper.

Contents of Paper: 1. Brake torque obtainable from induction motors. 2. Review of dynamic braking. 3. Analysis and design of compensated dynamic braking control system. 4. Applications.

AGM Paper #66

The Non-destructive Testing and Quality Control of All-Welded Steel Structures

John V. Hayward
Welding and Quality Control Engineer.
Alberta Branch, Dominion Bridge Co. Ltd.

The paper examines the basic principles, and the problems involved in setting up a weld testing and quality control program suitable for use in the construction of large steel weldments. The views expressed by the author have been developed over a number of years while working with Architects and Engineers on a variety of projects including heavy wall Pressure Vessels, Warships, Bridges and buildings all of which were fabricated entirely by fusion welding.

The need for Quality Control is explained, and to illustrate the current trends examples are taken from various sections of the welding industry, and the more important Codes are discussed. Three recent projects in Western Canada are described and details of the Non Destructive testing employed are given.

1. All-welded Plate Girder Highway Bridge, size 440' x 60' at Edmonton, Alberta completed 1961.
2. All-welded Rigid frame building 200' x 90' at Lethbridge, Alberta completed 1961.
3. S.P.C. Head office Building 14 stories, 270' x 43' at Regina, Saskatchewan completion date 1963.

The established systems of Non-destructive weld testing are described, together with an outline of their particular areas of usefulness, and their current state of aceptance. The suggestion is offered that none of the N.D.T. systems now available, can fully satisfy our present inspection requirements, and that the best results have been obtained when a number of the systems are used; each in the particular situations that are most favourable to their physical properties.

The dependence of the N.D.T. systems of today, upon the skill and integrity of the technicians employed in their use is discussed in detail. The Federal Government Standard for Industrial X-ray technicians is an excellent start, and similar tests to cover the personnel using Ultrasonic and Magnetic Particle testing systems are urgently required. Federal and Provincial Government testing of welding operators engaged in the structural steel industry is mandatory, and it is desirable that the Welding Inspector who is empowered to accept or reject welded products should himself be tested for a minimum level of skill and knowledge, and be duly certified.

AGM Paper #1

The Pipeline Flow of Capsules: Potential Industrial Application

G. W. Hodgson and Henry Bolt, M.E.I.C.,
Research Council of Alberta

Transportation is a matter of vital concern in the Canadian economy largely because of the magnitude of the distances separating areas of production from areas of consumption. Costwise, pipeline methods of transport lie between shipping and rail methods, and while inland waterways play a substantial and increasing role in Canadian transportation, there is nevertheless justification for trying to extend the application of pipeline methods to commodities not presently amenable to pipeline transport. Second generation pipelining, slurry pipelining, shows promise, b

is limited in its application, and recourse must be made to hird generation pipelining, in which the goods to be moved re placed in the fluid str as large capsules which flow s segments of the strean Theoretical and experimental ivestigational programs ar stabl ing a good understand- ig of the science of capsule pipelining, and it is now seful to consider the basic applications of such systems, nd also to consider some of the over-all technology in- olved. The applications would appear to center upon the iovement of grains, mineral solids and chemicals, since iese represent a major portion, about 25%, of the total ansportation traffic in Canada. Conventional oil and gas ipelines in Canada already account for about 20% of the tal freight traffic. The major cost in capsule pipelining, s in conventional pipelining, relates to the capital costs f the system. To this, however, must be added surcharges r additional packaging and handling equipment, and for iodest increases in pressure gradients. It is difficult to timate such surcharges with great confidence at this me, but there is reason to believe that capsule pipelining iay be able to enter at least some of the fields of trans- ortation of bulk commodities.

AGM Paper #54

esearch and Development Objectives

. B. Hunt, M.E.I.C.,
ice-President—Research and Development,
orthern Electric Company, Limited

Collectively, research and development has become big usiness. Well over half of the work in this field is carried it within industry, whose ultimate motive is to increase rofit for their shareholders. Industrial research must, there- re, be objective. To be objective it must be planned and ntrolled within the limits of the Company's current or iture interests.

Some of the so-called research and product develop- ent carried out by Canadian Companies is just another nction of engineering, dominated by manufacturing. Re- arch, to be effective, must have technical and financial eedom within authorized limits well defined by Company licy. It cannot be turned on and off like a tap as Company ofits rise and fall, or diverted to meet crash production ograms.

To establish objectives, research must be aware of arket requirements, current and future, as well as capa- lities of manufacturing. A co-ordinated team representing arketing, engineering, manufacturing and research, is erefore necessary to establish Company policy.

Dollars spent is no measure of the effectiveness of search and development. It must, in the long run, justify expenditures by increased Company profit. With the ge sums being spent today by individual Companies on search, top management must be fully informed well in lvance of development programs and the possible effect future manufacturing requirements and marketing ethods.

AGM Paper #18

Engineer Looks at Shelters

'an T. Jeffrey,
upervising Engineer, Special Projects Group,
oundation of Canada Engineering Corp. Ltd.,
ontreal, Que.

One of the most difficult and important problems day is to present to the man in the street, a realistic cture of nuclear effects as they would apply in case of ir. This is a very controversial subject and people are clined to let their feelings rather than their judgment rm their opinion. It also happens to be a very complicated bject and an answer in one location for a particular set conditions can, and usually is, very different than would ply somewhere else. There is a tendency for people with limited knowledge of the subject, to take one particular tail which may be technically correct and apply it in- scriminately to attempt to provide an answer which may be far from reality to the conditions that would actually apply. This leads to most of the confusion felt by the general public on this subject.

This paper discusses some of the more important problems in the nuclear field as they would apply to shelter survival. A number of engineering studies have been done for major industries in Canada with respect to the problem of survival and possible plant damage in a nuclear war. These have been done on an engineering basis assuming strikes on certain strategic targets and plotting from known measured data the resulting conditions as they would occur. The thinking required in these studies has made it very apparent that fallout is unquestionably the major problem and that also protection against it is almost as much a problem of education as one of shelters. This article dis- cusses in some detail, some of the more important aspects of the nuclear protection problems as they would apply to shelters and gives one a basis to assess realistically the value of shelters for the population as a whole.

AGM Paper #25

Progress in Power Distribution

R. E. Jones,
Contributing Editor, Electrical News and Enginering,
Bolton, Ont.

The distribution of electric power has grown rapidly since Edison started his system in 1882. Latterly the progress of this branch of enginering has been increasingly rapid with our industrial expansion.

Distribution is traced from the start with direct current to the transformer and alternating current followed by details of the evolution of the component parts of a system over the years.

Present practices are reviewed and in conclusion some predictions are made for the future.

AGM Paper #6

75 Years of Structural Steel

W. C. Kimball,
Assistant Chief Metallurgist, The Algoma Steel Corporation Limited, Sault Ste. Marie, Ont.

This paper surveys the use of structural steels from the first steel framed building in Chicago in 1888 to the latest buildings and bridges under construction in 1962. The steel specifications used are discussed and the develop- ment of the early specifications into the present steels is followed. Auxiliary uses of steel, other than as framing members, are also developed, leading to the present day all steel construction methods. The latest steel specifications are reviewed and some predictions are made of the struc- tural steel specifications of the forseeable future.

AGM Paper #42

Selection of Dike Freeboard and Spillway Capacity for Grand Rapids Generating Station

Ian William McCaig, M.E.I.C.,
Director and Hydraulic Engineer, H. G. Acres & Co. Ltd.
Fritz H. Jonker,
Hydraulic Engineer, H. G. Acres & Co. Ltd.
William Hamilton,
Project Engineer, H. G. Acres & C. Ltd.,
Niagara Falls, Ontario

The construction of the Grand Rapids development on the Saskatchewan River in Manitoba will create a large shallow lake in which winds will have a marked effect in raising the water level against the dykes, and in driving waves up the dyke slopes. The cost of increasing the height of the 15 miles of dykes, which are required to form the reservoir, makes a realistic estimate of these effects eco- nomically necessary.

Meteorological studies of wind frequencies and hydro- logical studies of extreme floods were combined with an economic assessment of the risks of overtopping of the

dykes. These studies showed that it was necessary to make the dykes secure against the effects of storms and floods of a combined return period of 5,000 years; that the effects of a wind storm of this probability were the controlling conditions for the design of the dykes; and that economy in spillway construction could be achieved by taking advantage of the differing seasons in which these phenomena are most likely.

The paper describes techniques used in computing the effects of waves on the dykes and shows how the heights of the various dykes were adjusted to allow for varying conditions of exposure to wave attack.

AGM Paper #2

Suspension Bridges for Material Handling

T. Lamb, M.E.I.C.,
T. Lamb, McManus and Associates Ltd., Calgary Alta.
R. N. McManus, M.E.I.C.,
T. Lamb, McManus and Associates Ltd., Calgary, Alta.

The problem of handling petroleum and natural gas products, granular and liquid materials across rivers, gorges and other difficult terrain often requires long span structures for its economic solution. Topography, foundation conditions, scour and ice hazards in rivers, together with other general considerations often indicate the suspension type of structure as the most suitable. While consideration has been given in Canada to suspension bridges for aggregate and earth fill handling, to our knowledge, in Western Canada the pipeline suspension bridges carrying natural gas, oil and liquid sulphur are the only ones in use at present. These structures vary in clear span from 600 feet across the Bow River near Calgary to 1670 feet across the Peace River at Taylor Flats, British Columbia.

The materials handling suspension bridge is different from the normal traffic structure in that its dead weight and stiffness are usually small for the length of the span. Furthermore the transmission of the product normally involves a travelling belt or pumping operation which impresses a natural vibration upon the structure. Special devices must therefore be designed to overcome the inherent flexibility of the structure so that it may resist these vibrations, together with the effects of wind.

Each of the nine overhead river crossings in Western Canada has been designed to suit the particular problem and location. In the case of the Peace River Crossing at Taylor Flats and the Fraser River Crossing at Flood, B.C. major structural towers more than 210 feet high were fabricated from ordinary pipe. This was necessitated by the shortage of structural steel and fabricating space, together with the urgency of the project in 1956. The calculations involving the stability of these unbraced towers, the rigidity of the wind system and the general deformation characteristics are interesting from the engineering point of view. These structures have been in operation for periods in excess of five years and records show their structural behaviour to be essentially as predicted.

The more general use of suspension bridges can be anticipated for transportation of other materials as development calls for construction of large projects in difficult terrain.

AGM Paper #43

Some Aspects of the International Background of Columbia River Projects in Canada

R. C. McMordie, M.E.I.C.,
Manager, Engineering and Operations,
B.C. Power Commission, Victoria

A brief description of the Columbia River will be given noting that the river is the fourth largest river on the North American Continent; over 1,200 miles in length; has a drainage area of 259,000 square miles: a total developable head of 2,500 ft. on the mainstem; an average discharge at the mouth of 250,000 cfs; and a number of other statistics.

In order to obtain a perspective of Columbia River power, the total power potential of the river will be shown in relation to other important power rivers, for example, the St. Lawrence. This perspective will also include the significance of the Canadian potential of the river in relation to the present installed capacity of the B.C.'s public utilities.

The history will begin with the reference on March 9, 1944 to the International Joint Commission of the problem of determining whether a greater use than is now being made of the waters of the Columbia River System would be feasible and advantageous to the United States and Canada. The establishment of the International Columbia River Engineering Board will be described, followed by a brief resume of the International Columbia River Engineering Board's report of March 1, 1959. Specific points noted in the conclusion of the report will be discussed, followed by an outline of the background material which led to the engineering principles recommended by the I.J.C.

The report on the I.J.C. principles relating to downstream power and flood control benefits, December 29, 1959, will be discussed, with particular emphasis on the timing and sequence of project development on the river and its effect on Canadian downstream benefits.

The Columbia River Treaty will be discussed under the following headings:

(a) Undertakings by Canada and U.S.A. (b) Determination of Downstream Power Benefits. (c) Delivery of Power and East-West Standby Transmission. (d) Kootenay River, Libby. (e) Provisions for carrying out the Treaty. (f) Treaty Terms.

Various achievements of the Treaty will be discussed, for example recognition of the downstream benefit principle, benefits to Canada, etc. An analysis will be made of a number of economic aspects of Columbia development including the "net and gross benefit question". The considerations which support the conclusion that the Arrow Lakes storage project be one of the first projects to be developed will be reviewed in some detail. A discussion of the storage aspect of the Columbia River may be included depending upon the status of the International negotiation at the time the paper is being presented. Developments, if any, in the proposed electrical interconnection between the B.P.A. System and the B.C. Hydro System will be described and B.C. Hydro's plans in this regard will be shown. The paper would be illustrated with a general map of the Columbia with project sites noted, together with suitable photographs of the Arrow, Duncan and Mic[a] damsites.

AGM Paper #6

Montreal Central Terminal Track Ventilation System

G. V. Meagher, M.E.I.C.,
Dilworth, Secord, Meagher & Associates Ltd., Toronto
E. Eggman
Senior Engineer, Dilworth, Secord, Meagher & Associat[es]
Toronto
I. J. Billington, M.E.I.C.,
Senior Engineer, Dilworth, Secord, Meagher & Associat[es]
Toronto

The complex of buildings of Place Ville Marie an[d] Canadian National Railways in and about the Montre[al] Central Terminal has covered trackage in this area from th[e] Mount Royal tunnel mouth to Lagauchetiere Street. Th[e] anticipation of this condition a few years ago required th[e] CN to consider conversion to all electric train operation [in] the station area or the ventilation of the track level [to] collect and remove diesel fumes. The latter alternative w[as] established as more economic and the subject paper di[s]cusses the evolution of a ventilation concept and develo[p]ment of a suitable design.

Initial feasibility studies indicated a solution throug[h] temporary containment of engine exhausts by means [of] appropriate ceiling configuration with the collection of the gases by a continuous system of plenums adjacent to th[e] tracks at ceiling level. Collected gases would be transport[ed] for discharge at the two ends of the system.

Model tests were conducted to confirm feasibility [of] this concept, develop a satisfactory plenum geometry an[d] establish first order values for flow rates. Full-scale e[...]

eriments were subsequently undertaken in the station on 250 ft test section of track.

The final design, which is in process of installation, rovides ventilation over 12 tracks of average length of 100 ft. Station geometry, structural limitations, corrosion roblems and difficult working conditions have demanded unorthodox design with a degree of sophistication nusual to sheet metal work. The all-aluminum design is ighly unitized to facilitate prefabrication and quick instal- tion. Space limitations have favoured axial flow fans, thus roviding an ancillary requirement of noise attentuation. alancing of flows over long system length has been ccommodated by variable orifices in the plenum throats et to calculated values for first approximation and adjusted or final setting under flow conditions.

The installation is quite monumental involving about 3,000 ft. of collection system over an area of some 460,- 00 sq. ft., using 150 tons of aluminum sheet and extru- ons. Flow rates and power levels however have been inimized to values of 450,000 cfm and 300 total HP spectively.

AGM Paper #26

echnical Information Service of the National Research ouncil

. E. McBurney, Chief, National Research Council echnical Information Service

The paper describes the operations of the National esearch Council Technical Information Service, includ- g some background as to its origin and factors affecting s development into the present organization. The service rovides, free of charge, up-to-date technological informa- on on the properties and processing of materials, the fficient operation of industrial facilities, new industrial developments, and the results of scientific research. This is done through personal visits by engineers, having university degrees and many years of industrial experience, to individual firms. They are backed up by a group of similar engineers in Ottawa who have access to wide and varied sources of information. The nature and extent of the field services established across Canada are described, together with some detail of the techniques employed by the field officers and the difficulties they face in visiting firms and obtaining solutions for their widely varying problems. Similarly the organization and functions of the central staff at Ottawa, which answers those problems referred to it by the field staff or directly from enquirers, are outlined. Their sources of information, their contacts with foreign information centres, the fundamental considerations governing the form and coverage of answers and factors affecting the efficiency of their work, are discussed. The future plans and organization of the service are described and the advice and comments of the members of the Institute are warmly solicited to assist in shaping the Technical Information Service and its activities in the years to come.

AGM Paper #17

Design and Construction of the Brazeau Dam

J. K. C. Mulherin, Chief Construction Engineer, Montreal Engineering Company, Montreal.

The Brazeau Storage Dam, on the Brazeau River, in Alberta, is 210 feet high and contains 4,000,000 cubic yards of earth fill. It is the first major unit of the $40,000,- 000 Brazeau Storage and Power Development to be completed, and besides providing storage to be released during the low flow period of the North Saskatchewan River, it raises the Brazeau River to an elevation at which it can be pumped into a high level canal 12 miles long leading to

the headworks of the Big Bend Power Plant where 400 feet of head will be utilized to develop an ultimate 800,000 horsepower.

This paper describes the design of the unwatering conduits, to cope with velocities in excess of 60 feet per second, and the design of the earth fill in view of the varying qualities of earth fill material available. Also described are the tests and experiments carried out in the field to obtain smooth surfaces and joints in the conduits, to control earth fill placement, and to obtain satisfactory foundations for the structures.

AGM Paper #65

High-Pressure Hydraulic Control Systems

P. N. Nikiforuk, M.E.I.C.,
Mechanical Engineering Department,
University of Saskatchewan, Saskatoon.

The subject of this paper is high-pressure hydraulic control systems. The paper is divided into three more-or-less distinct parts. The first part is introductory. It describes the nature and the status of high-pressure hydraulic control systems. It also includes a comparison of the merits of electrical, pneumatic and hydraulic control systems in order that the specific advantages and disadvantages of the latter can be clearly understood. The second part discusses the design and analysis of these systems. It starts with a description of these load characteristics which influence system design and continues with a description of the more common types of components available. It is then shown how this data can be used to realize a physical system. The third and last part of the paper is devoted to practical considerations and typical applications. Included with this section is a brief description of the high-pressure hydraulic installation which is located in the Mechanical Engineering Department at the University of Saskatchewan.

AGM Paper #58

Aspects of the Aeroelastic Behaviour of Bluff Cylinders

G. V. Parkinson, Associate Professor,
Mechanical Engineering, University of British Columbia, Vancouver.

Under certain conditions, elastically supported bluff cylinders will exhibit oscillations of considerable amplitude in a steady transverse wind. In the paper, some existing aerodynamic theories of these oscillations, and available experimental evidence are examined. The theories relate the oscillations to the influence of the separated wake from the cylinders in different ways, either as a resonance phenomenon between the elastic system and the wake considered to be organized as a Kármán vortex street of regular frequency, as a response of the elastic system to random excitation from a turbulent wake, with no dominant frequency, or by assuming a quasi-steady model, using the stationary flow pattern about the cylinder as a function of attitude to the wind in the dynamical equations.

Since the amplitudes of oscillation, as well as the tendency to oscillate are of interest, the possibilities of using non-linear dynamical equations in the above theories are considered. In the existing theories of the oscillations, the aerodynamics is purely experimental. Possibilities of using ideal fluid field theory are considered. The effect of the sectional shape of the cylinder in relation to the separated wake is discussed.

AGM Paper #34

The Production and Use of an Animated Film for Teaching Kinematics

G. F. Pearce, M.E.I.C.,
Assistant Professor of Mechanical Engineering,
University of Waterloo, Waterloo, Ont.

Many areas of engineering today have experienced significant extensions of knowledge during the past decade. This poses a problem for the engineering teacher, i.e., ho to get the student to absorb more material in the allott time. One solution to the problem is to use more effecti visual aids, which give the student such a clear conce tion of the elementary principles that he can progress the advanced work more rapidly.

This paper is concerned with the production and u of an animated film illustrating some principles of ki matics. The actual production of the film is described; t drawings used for animation, the photographic techniqu and the equipment used are shown; and finally the fi itself will be presented at the Annual General Meetir The film (10 minutes running time) shows the displac ments, velocities, and accelerations in a four-bar ba mechanism. The method of obtaining the acceleratic using a digital computer are explained. The particu conditions of maximum velocity and maximum accelerati are strikingly portrayed when viewing the film and t superiority of the animated presentation over the us static presentation is evident.

AGM Paper

Place Ville Marie — Structural Steelwork

C. J. Pimenoff, M.E.I.C.,
Dominion Bridge Company, Limited.
J. Daccord, A.M.E.I.C.,
Dominion Structural Steel Division,
Canada Iron Foundries, Limited.

This paper deals with the fabrication and erection structural steel for the Place Ville Marie Developme consisting of The Royal Bank of Canada Cruciform Bui ing soaring over 600 ft. above Dorchester Street, street level plaza and the Cathcart Building. Nea 60,000 tons of steel were fabricated and erected by "Dominion Bridge-Dominion Structural Steel" Joint V ture. Due to some unusual design features of the structu steel frame, special problems were encountered both the shop and in the field. This paper describes the des of the more important connections, the fabricating te niques used in making some of the heaviest steel build components ever built in Canada and the solution of so special problems in erection. A general description of project and of the design of structural framework will dealt with in two other papers, complementary to t one.

AGM Paper

Variations of Snow Loads on Roofs

W. R. Schriever, M.E.I.C., and *B. Peter,*
Division of Building Research, National Research Coun

Because the snow load is usually the critical load which roofs in Canada must be designed, the assum magnitude and distribution of the design snow load h a considerable effect on the safety and the cost of structure. The treatment of this load in building codes compared in the paper to the actual snow loads found buildings with particular attention given to the effect of wind and of the shape of the structure as well as clim variations across Canada. An extensive country-wide sur of actual snow loads on roofs and on the ground be conducted by the Division of Building Research of National Research Council is described and future proved approaches to the specification of snow loads indicated.

AGM Paper #

Operation of the Belleville Transit System

S. Sillitoe, M.E.I.C., *Production Superintendent,*
Northern Electric Co. Ltd., Belleville, Ont.

Almost without exception Municipal Transit Syste in Canadian cities of all sizes find themselves in the p tion of requiring a subsidy or incurring a deficit fo

mber of reasons, the most significant being the competi-n of the private automobile. Smaller cities find an addi-nal deterrent to a completely successful operation, in or street patterns and frequency of service required to mpete with relatively short walking distances in down-vn areas; and in very light patronage for long periods the day in outlying and recently annexed areas. The lleville Transit System is no exception. The paper deals th the problems arising from the City taking over the vately owned Bus System and placing it under the juris-tion of the Belleville Transit Commission with the two-d purpose in mind of extending the service to annexed as and operating on a self-supporting basis. It de-ibes the observations made as experience was gained, d more specifically the lessons learned from experimental ites, the public reaction and some of the methods used plan the complete system operation. The progress made date is graphically presented, together with various route ps.

AGM Paper #47

ilrace Improvements at the Beaumont Hydro Electric velopment

G. Smallridge, M.E.I.C., *Hydraulic Engineer,*
e Shawinigan Engineering Company Limited, Montreal

At the Beaumont Hydro-Electric Development on the Maurice River, Quebec, an extensive tailrace excavation rried out by a large walking dragline resulted in a gain head of over 17 feet. This paper describes the hydraulic sign studies, model tests, and execution of the field work th particular comments on the problems associated with two river crossings and the comparison of actual and edicted results.

AGM Paper #4

illed, Cast-in-Place Piles and Caissons

B. Torchinsky, M.E.I.C.,
B. Torchinsky & Associates, Consulting Engineers,
skatoon, Saskatchewan.

This paper will deal with developments, during the st 10 years, in the use of cast-in-place concrete piles and ssons in Western Canada. A description of the soil types which such foundation units are most readily installed d some aspects of design criteria will be presented. The thor will also discuss some of the problems encountered construction and some special techniques used to cope th these problems.

AGM Paper #10

thotropic Design in Modern Bridge Engineering

S. Troitsky, M.E.I.C., *Bridge Engineer,*
undation of Canada Engineering Corporation Limited,
ntreal

The contents of the proposed paper will consist of following five main parts:

General Data on Development of Orthotropic Bridges
is introductory part contains basic data and a brief vey of the development of modern steel bridges of orthotropic system. Data on European practice. Factors luencing the development of orthotropic bridges are tlined: shortage of material, progress in structural analy-, improved welding technique. Conception and develop-nt of the orthotropic system as based on experimental l analytical data. The battledeck floor and gridwork

system. Construction details of the orthotropic system, deck types, performance, structural efficiency.

2) *Analysis of New Bridge System and Method of Design* Anatomy and structural behaviour of orthotropic type bridges. Application of the methods of the Theory of Elasticity for Stress Analysis of the orthotropic deck. Three-dimensional stress distribution. Superposition of componental stresses. Buckling and torsional rigidity. Suggested specification for live load distribution, materials, allowable stresses and permissible deflections.

3) *Advantages.* Range of application. Economics. Weight savings due to structural performance, advanced design methods, types of steel, full utilization of materials, increased factor of safety, welded connections. Comparison with conventional type bridges, composite, prestressed steel. Great load-carrying capacity, reduction in number of field connections. Influence on substructure design.

4) *Examples of Existing and Proposed Bridges.* Creation of new types: boxes, cable-braced, middle support bridges. Description of few large steel bridges of orthotropic design to illustrate the general trend in this advanced type of construction. Typical representative bridges: Plate Girders, Arches, Suspension.

5) *Current Development, Trends and Research.* Simple but accurate methods of structural analysis. Application of electronic computers. Research in vibrations, fatigue, corrosion, deck protection. Experimental investigations on models and full-size tests regarding deck system behaviour under loading. Simplified and more efficient structural members, connections, shop fabrication, welding. Evaluation of design criteria: permissible stresses, deflections, ultimate strength.

AGM Paper #3

The Tilting of a Blast-Furnace Foundation

Nyal E. Wilson, McMaster University and
A. H. Atkinson, Prack and Prack, Hamilton.

The paper describes the remedial measures taken t stabilize a large blast furnace foundation which started t tilt during construction. The foundation slab, 66 feet i diameter and 6 feet thick, was supported by 250 twelve inch closed-end pipe piles; the piles were driven throug seventy feet of soft clay and silt to refusal in a ten-foo layer of hard-pan. The pile-driving took ten days and th foundation slab, containing over 1,000 cubic yards of con crete, was poured two months later. A few days after th foundation slab was poured, the excavation, 24 feet dee and 50 feet long was made adjacent to the blast-furnac foundation. Within two weeks, the entire slab, which a this stage weighed 2,500 tons, moved four inches horizon ally. It appears that the foundation pivoted about the end of the piles supported by the hard-pan, but it is not pos sible to prove this as vertieal movements were no measured. However, it is known that settlement did no take place. High pore-water pressures were generated i the layer of soft clay and silt during pile-driving an these were not dissipated due to the low permeability o the soil. These pore-water stresses caused a reduction i effective stresses and thus reduced the horizontal restrai for the pile group. Consequently, as soon as the adjacen excavation was opened, the foundation slab started to cree horizontally. It was decided to stabilize the foundation sla in its new location. Heavy ground beams were poured con necting the foundation slab to two "strong-points". Th "strong-points" were formed by driving composite ste and concrete piles in the form of a tripod and anchorin these piles firmly into the shale bed-rock.

ANNUAL MEETING PREPRINTS

Preprints of all Annual General Meeting papers abstracted on the preceding pages will be available at the Meeting in Montreal. They also can be obtained from The Engineering Institute of Canada, 2050 Mansfield St., Montreal 2, Que.

DOMINION RUBBER ANNOUNCES

WEATHERGARD

THE NEW MORE DURABLE CONVEYOR BELT COVER

- Resists ozone destruction
- Resists weather checking
- Resists flex cracking
- Resists aging and hardening

ollowing years of research, Dominion Rubber is ow able to introduce an important advance in onveyor belt covers — WEATHERGARD.

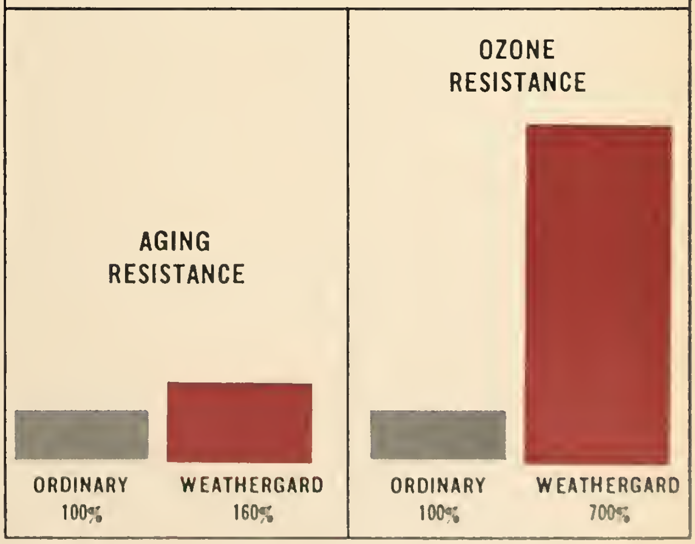
WEATHERGARD is made possible through e development of new additives and processing chniques which successfully protect rubber belt-g against weathering and the effects of ozone. his unique protective cover is incorporated in oth Dominion Matchless and Giant grade con-eyor belting as a standard feature.

In recent tests, the WEATHERGARD cover as shown to afford seven times greater protection gainst cracking caused by ozone. In addition, sistance to aging proved to be greatly increased.

For extra durability and longer life specify ominion Matchless or Giant Conveyor Belts — ow with the added protection of WEATHER-ARD.

WEATHERGARD cover is standard on ominion Conveyor Belting at no extra cost.

COMPARE THE RESULTS OF TESTS BETWEEN WEATHERGARD AND OTHER BELTING



ENGINEERED RUBBER AND PLASTIC PRODUCTS FOR EVERY INDUSTRY

M-4008-1

Dominion Rubber

Mechanical Goods Division

Month to Month

E.I.C. ELECTIONS AND TRANSFERS

A number of applications were presented for consideration and on the recommendation of the Admission Committee, the following elections and transfers were effected at a meeting of council on March 10, 1962.

Applications through Associations

By virtue of the co-operative agreements between the Institute and the Associations the following elections and transfers became effective March 10, 1962.

ALBERTA

Member: S. Shepetys.

Associate Members: H. D. Hepburn.

NOVA SCOTIA

Member: A. W. Baxter.

STUDENTS ADMITTED

Nova Scotia Technical College: A. E. Arklie, G. R. Bishop, L. L. Bryson, R. R. Burnham, G. L. Caudle, J. D. Chisholm, B. P. Cormier, A. T. Cote, D. H. Crocker, B. J. Cunningham, A. Dachlan, A. Dahlan, P. P. Devereaux, D. J. Di Cesare, G. B. Dillon, I. E. H. Duvar, B. Cee, A. L. Hachey, P. Henderson, J. J. Henley, J. M. James, T. Leung, R. F. Lusby, H. F. MacDonald, S. G. T. MacDonald, J. C. MacKinnon, D. J. MacMullin, C. A. Maguire, D. L. Mason, E. S. Matheson, C. W. May, J. McCormick, J. T. McDonald, R. D. McLatchy, K. F. McManus, J. A. Murphy, C. W. Murray, D. C. Muttart, E. J. Nellis, R. M. Nelson, D. F. Parsons, J. M. Philpott, J. H. Pike, D. W. Power, E. J. Power, T. A. Rankin, J. H. Rogers, R. T. Rose, G. J. Samson, A. D. Solomon, J. D. Soper, B. C. Thomson, J. M. Timmons, Y. W. Tsang, Wardijasa, R. V. Wells, W. L. Wheeler, S. Wijotosdepadmo, C. H. Wintermeyer, S. Wongsowmoto, K. E. Woodhead, H. F. Young.

Queen's University: P. G. Barr, J. P. Bayne, B. D. Boyce, B. A. Branch, K. A. Brenner, R. D. O. Brewer, H. A. Briggs, A. T. Bruce, A. W. Brueton, R. J. Bulmer, R. A. Campbell, E. J. Cashman, H. T. Chan, J. A. Clarke, L. P. Cooke, J. C. Davis, J. H. Day, M. P. Dolbey, J. G. Elmitt, W. G. N. Fleming, S. J. R. Fosbury, D. B. Grant, D. W. Hagemann, W. R. Hardy, P. G. Harle, R. I. Hodgson, N. L. Hunter, R. J. Kerr, D. C. Kilby, G. T. Knights, J. P. Krupicz, D. B. Main, D. S. Marshall, G. O. Misener, R. E. Moore, R. E. Morin, P. M. Osborne, I. Osis, W. J. Pickett, R. W. Price, G. R. Racine, H. A. Rasanen, B. E. Roininen, P. N. Ross, R. L. Sargant, M. C. Sekerak, H. M. J. Shurtleff, J. D. Simonett, B. A. Smith, D. H. Smith, B. L. Stevens, M. E. Vigrass, M. J. Walker, D. R. Woods, D. C. Wright, T. Y. L. Yung.

University of Sherbrooke: G. Arel, G. Baillargeon, B. Beaulieu, S. Bedard, A. Bergeron, R. Blanchard, P. Boisvert, D. Boucher, G. Boucher, A. Brais, N. Bruneau, A. Champagne, C. Coté, M. Coté, G. R. Cyr, R. Cyr, D. H. D'Amours, R. Desmarais, V. Dube, P. A. Duquette, R. Gaudet, R. Gervais, R. R. Girard, R. R. Houle, J. Janelle, G. Lacharité, R. G. Lacroix, L. Lahaie, M. Langlois, R. Lavoie, Y. Lessard, C. L. Léveillé, R. Lupien, F. Martineau, R. Mercier, Y. Messier, B. Normand, M. Ouellette, R. Patry, J. Perreault, J. M. M. Perreault, J. Roy, N. Roy, P. A. Roy, G. Ruel, M. St. Louis, R. Savard, R. Taillefer, J. Tardif, A. Turgeaon, N. Vachon, J. C. Vallée.

University of Waterloo: D. R. Austin, M. D. Clarke, R. A. Clarke, D. Edwards, R. D. Glushkoff, D. O. Hill, J. D. Hubbell, B. E. Jank, C. A. Mills, D. Pizak, J. C. Robertson, J. C. Stirrat.

University of New Brunswick: D. F. Andrew, E. W. Arnold, H. A. Bursey, J. Butt, G. A. Caissie, D. R. Capson, W. T. Cushing, L. R. Elliott, R. Fafard, K. E. Fynn, A. L. Gaunce, W. H. Gentleman, A. C. Golding, D. L. Halliday, W. J. K. Holland, W. R. Jones, R. B. MacQuarrie, C. R. Matthews, G. R. McDonald, I. B. Milner, E. D. Milton, G. C. Munn, C. L. Munroe, W. A. Nesbitt, D. H. Noble, T. A. Parsons, J. D. W. Peters, A. W. Petrie, T. A. Robertson, C. A. Robichaud, W. H. Robins, G. E. Shaw, A. V. O. Skeat, F. M. Sullivan, G. A. Thompson, A. F. Van der Wey, F. A. Wetmore, G. D. Wheeler, S. C. K. Wong.

Saint Mary's University: L. R. Blanchard, G. D. Campbell, E. L. P. Chiasson, W. G. Comeau, J. G. L. Cormier, A. L. Geddry, R. J. Gillespie, K. H. Kho, A. H. Robinson, W. M. Roma, R. D. Taylor, A. L. Thibo deau.

Mount Allison University: W. H. Berridg H. J. Werner Bohn, R. E. Brown, D. I Carter, R. J. Desborough, J. O. Eta, L. W McEwen, W. H. Meadows, M. S. Mill J. A. Talbot, R. R. Young.

University of Toronto: W. J. Dowke M. J. Heydon, P. W. K. Ho, T. D. Kian P. Mannsfeldt, W. I. Marcovitch, G. M McCormack, J. D. McCulloch, J. A. C McKnight, A. D. Orcheson, D. L. Robin son, J. C. Thompson, A. R. Walsh.

Sir George Williams University: A. A Davies, J. R. R. Deslauriers, G. Duroche V. G. Fodor, J. Kossegi, W. P. Romanow ski, J. L. Sauve, P. Torok, J. Vallianato

University of Alberta (Calgary): R. Arm strong, K. E. Bagnall, R. D. G. Coles, R. E Dunbar, R. G. French, C. W. Gillies, J. A Pinter.

University of Alberta (Edmonton): S. V Benediktson, R. C. Fisher, R. F. Manuel.

McGill University: J. V. Branch, H. N Chance, H. W. Griffiths, C. S. Russe P. T. Sinclair, D. R. Smith, H. E. Wallace

Laval University: A. Bernard, M. Biror R. Bordeleau, P. Desaulniers, G. Pelchat A. F. Roy.

Memorial University: R. J. Adey, D. R Follett, R. W. Little, R. E. Moody, T. L Sutton.

Dalhousie University: R. J. Fell, C. F Jireada.

St. Francis Xavier University: W. J Dolan, M. T. McSheffery.

University of British Columbia: J. A Jamieson, R. A. Strachan.

Ontario Agricultural College: D. E. Gib bons, J. J. Hogan.

Ecole Polytechnique: C. Chagnon.

Acadia University: A. J. Crosby.

Loyola College: P. J. Conlon.

St. Joseph's University: E. Lagacé.

McMaster University: D. G. Watt.

Carleton University: B. F. Dewis.

The Seventy-Sixth Annual General Meeting of the Engineering Institute of Canada will be held on Tuesday, June 12, 1962, at the Queen Elizabeth Hotel, Montreal, P.Q., between the hours of 9:00 a.m. and Noon. This meeting will receive the report of the official auditors, the Annual Report of Council, Committees, Representatives, and Branches, and such other business as may come before the meeting.

Garnet T. Page, M.E.I.C.

Garnet Page

General Secretary

Coming Events

American Institute of Electrical Engineers, Conference on Electrical Problems in the Cement Industry, St. Louis, April 3-5.

American Society of Mechanical Engineers, Society of Advancement of Management, Management Engineering Conference, New York, April 5-6.

American Welding Society, Annual Meeting and Welding Exposition, Cleveland, April 9-13.

(Continued on page 99)

75th ANNIVERSARY GENERAL AND PROFESSIONAL MEETING OF

THE ENGINEERING INSTITUTE OF CANADA

ne 12-15, 1962 ▪ Queen Elizabeth Hotel, Montreal

Registration

Advance registration through E.I.C. Headquarters closes June 2nd.
Registration opens at 12 noon Monday, June 11th, at the Queen Elizabeth.

Accommodation

The Queen Elizabeth is headquarters for the meetings and other events, but alternate accommodation will also be available at other hotels and motels in the area.

Technical Program

The technical program is listed on the following pages.

Ladies Program

An attractive, varied and interesting ladies program is being planned. Detailed information will be included in advanced mailing which will be sent to all members.

75th Anniversary

In addition to an outstanding technical and social program, a number of special events are being planned to mark the 75th anniversary of the E.I.C.

Committee

Chairman: C. G. Kingsmill

Vice-Chairman: Jacques Benoit

Secretary: G. M. Boissonneault

Technical Papers

Bridge and Structural

"*Variations of Snow-loads on Roofs*".
W. R. Schriever and B. Peter

"*Suspension Bridges for Materials Handling*".
T. Lamb and Dr. R. N. McManus

"*The So-called Shear Strength of Concrete Beams*".
Dr. G. Kani

"*Drilled, Cast-in-Place Piles and Caissons in Western Canada*".
B. B. Torchinsky

"*Stabilization of Foundations by Soil Cement Grouting*".
G. T. Keith and H. Sabier

"*Steel Structures—a 75-year Development*".
W. C. Kimball

"*Place Ville Marie—Structural Steelwork*".
C. J. Pimenoff and J. Daccord

"*Construction Features of the Place Ville Marie Project*".
T. M. Phelan

"*The Structural Design of the Place Ville Marie Project*".
J. E. Brett, R. P. Ouelette and R. R. Nicolet

"*Orthotropic Design in Modern Bridge Engineering*".
M. S. Troitsky

"*Unusual Hangar Design for Dorval*".
E. A. Dahl, M.E.I.C.

"*Structural Features of the TCA Overhaul and Maintenance Base Hangars at Dorval, P.Q.*".
E. A. Dahl, M.E.I.C.

"*Soil Cement Construction*".
E. B. Garrett

Chemical

"*The Engineering Operation of Large Pipelines*".
C. D. Bailey, M.E.I.C.

"*The Pipeline Flow Characteristics of Crude Oil*".
Dr. A. R. Ritter and Dean W. Govier

"*Engineering Aspects of Aluminum Pipe*".
Not yet known.

"*Pipe Line Flow of Capsules*".
H. S. Ellis and/or G. W. Hodgson

Civil

"*Design Concepts of Brazeau Development including River and Hydrology Studies*".
K. G. Brittain, M.E.I.C. and J. L. Reid, M.E.I.C.

"*Design and Construction of the Brazeau Dam*".
J. K. C. Mulherin, M.E.I.C.

"*An Engineer Looks at Shelters*".
A. T. Jeffrey, M.E.I.C.

"*The Isolation from Railway Induced Vibrations of the Buildings in the Place Ville Marie Project*".
J. E. Brett, M.E.I.C.

"*Some Aspects of the Wind Loading of Structures*"
A. G. Davenport, M.E.I.C.

"*The Effect of Slimes on Open Channel Transpo[r]t [o]f Fluidized Solids*".
R. W. Ansley, M.E.I.C.

Communications, Electronic[s] and Automation

"*Electronics and the Future*".
W. L. Haney

Electrical

"*Progress in Power Distribution*".
R. E. Jones

"*Operation of Technical Information Service [o]f N.R.C.*".
R. E. McBurney

"*Some Aspects of Research in Britain on Cables [a]nd Over-head Lines*".
Eric E. Hutchings

"*Polyphase Transistors Magnetic Inverters*".
Prof. C. H. R. Campling, J. A. Bennett and D. O'Hara

"*A New Approach to the Measurement of Los[s] [i]n Magnetic Steel*".
J. S. MacKelvie, H. Hollitscher and Dr. E. Elgar

"*Analogue Computer Simulation of Ship Propul[sion] Systems*".
W. A. Wyeth

"*Economics of Heavy Water Reactors*".
J. R. Dickinson

"*The Research Man Considers the Future of Electr[ical] Engineering Imaginatively*".
W. L. Haney

"*Compensated Dynamic Braking of 3-Phase Wo[und] Rotor Induction Motors*".
G. Hansen

Education

"*Mining Engineer Education*".
Prof. A. V. Corlett

"*The Production and Use of an Animated Film [in] Teaching Kinematics*".
Prof. G. F. Pearce

Half-Day Panel Discussion on
"*The Image of The Engineer—The Viewpoint of [the] Universities*".
Panellists: Dean H. Gaudefroy, Dean Da[vid] Myers, Dean J. Hodgins, Prof. James Ham a[nd] Prof. A. Porter

Technical Papers

otechnical

"ttlement Studies of Mt. Sinai Hospital, Toronto".
AL D. CRAWFORD AND K. N. BURN

"e Tilting of a Blast Furnace Foundation".
F. NYAL E. WILSON AND A. H. ATKINSON

"ndations for the Port Mann Bridge, B.C.".
ef Engineer at B.C. Highways)

"atment of a Landslide Problem in B.C.".
C. THURBER

"mour Dam, Earthwork and Foundation Design".
F. RIPLEY

"Adam Beck No. 2. Pumped Storage Reservoir
gn, Construction and Performance".
M. TAYLOR
o Listed Under Hydro-Electric Div.).

"lure of a Silo on Varved Clay".
J. EDEN AND M. BOZOZUK

dro-Electric

"olution of Construction Methods in the Hydro-
tric Field".
R. L. HEARN AND DR. R. E. HEARTZ

"ection of Dike Freeboard and Spillway Capacity
he Grand Rapids Generating Station".
cCRAIG, F. M. JONKER AND W. HAMILTON

"ne Aspects of the International Background of
umbia River Projects in Canada".
C. MCMORDIE

"erating Experiences in a Hydro-Electric Plant
ling a Semi-Isolated System".
G. GREEN

"ttom Outlets under High Head".
. BERTRAND AND E. PARISET

"mano Tunnel Operation and Maintenance".
. COOKE, J. W. LIBBY AND J. T. MADILL

"ilrace Improvements at the Beaumont Hydro-
tric Development".
G. SMALLRIDGE

"e Design and Construction of a 345 Kv. Transmission
Using Guyed and Rigid Structures".
F. CROWLEY AND S. T. RUDIKIN, M.E.I.C.

"rsimis II Powerhouse Plant Arrangement".
DGAR RANSOM

"Adam Beck No. 2. Pumped Storage Reservoir
ign, Construction and Performance".
M. TAYLOR (Also listed in Geotechnical)

"d Rock Falls Project".
A. FORRESTER

"rward Planning Studies Involving the Economic Full
ply Level of Grand Rapids Generating Station of
nitoba Hydro".
A. BATEMAN AND K. RENGER

Management

"Research and Development Objectives".
A. B. HUNT, M.E.I.C.

"Engineers and the Canadian Economy".
J. P. FRANCIS

"Operation of the Belleville Transit System".
S. SILLITOE

"2 Hour Panel Discussion on Symposium on Management".
PANELLISTS: DR. A. H. ZIMMERMAN, D. NESBITT AND R. WINTERS

Mechanical

"Aspects of the Aeroelastic Behaviour of Bluff Cylinders".
PROF. G. V. PARKINSON

"Mechanical Services on the Place Ville Marie Project".
MUNRO H. KERT

"The Alignment of Large Diesel Engines".
Name not yet known (per R. C. MCMORDIE)

"Montreal Central Terminal Track Ventilator System".
GEO. V. MEAGHER, M.E.I.C., I. J. BILLINGTON AND E. EGGMANN.

"Convective Heat-transfer for a Helical-Fin Tube in Longitudinal Flow".
PROF. R. E. CHANT, M.E.I.C.

"The Effect of Exterior Building Construction upon the Cost of Heating and Air Conditioning Systems".
PROF. G. H. GREEN

"High Pressure Hydraulic Control Systems".
PROF. P. N. NIKIFORUK

"Non-Destructive Testings of Welds".
J. B. HAYWARD

"Design & Construction Aspects of the Beechwood Third Unit".
G. E. GUNTHER

"Absolute Measures of Work Management".
W/C A. B. HOWELL, R.C.A.F.

"Steam and Gas Turbines".
E. R. SIGNER

Mining

"Unusual Problems in Development of Caland Mining Operation at Steep Rock Lake".
F. W. WHITMAN, S. A. REIPAS AND DR. R. M. HARDY.

"Some Aspects of Strata Control in Mining".
PROF. D. F. COATES

"New Developments in Mining Engineering Technology".
Joint paper by Colleagues of DR. CHARBONNIER

"New Types of Mineral Classification Equipment".
DR. R. P. CHARBONNIER

Annual Meeting

Sunday, June 10th

Annual Meeting of Council	7:00 p.m.

Monday June 11th

Committee on Branch Operations	9:00 a.m.
E.I.C. Conference on Engineering Education	9:00 a.m.
Committee on Technical Operations	9:00 a.m.
Joint Luncheon, All Conferences	12:30 p.m.
Committee on Branch Operations (Continued)	2:00 p.m.
Open House—Muriel's Room	8:30 p.m.

Tuesday, June 12th

Authors' breakfast	7:45 a.m.
Annual General Meeting	9:00 a.m.
Muriel's Room	12:00 noon
Opening Luncheon	12:30 p.m.
Students' Conference	2:00 p.m.
Technical Sessions	2:30-5:30 p.m.
Special Entertainment	6:00 p.m.

Wednesday, June 13th

Authors' breakfast	7:45 a.m.
Association of Consulting Engineers, Directors' Meeting	9:00 a.m.
Technical Sessions	9:00-12:00 noon
New Council Meeting	9:30 a.m.
No Organized Luncheon	noon
Students' Conference 2nd Session	2:00 p.m.
Technical Sessions	2:00-5:00 p.m.
Muriel's Room	6:30 p.m.
Dinner Institute's official visitors, and President Ballard's retiring address	7:00 p.m.
Special entertainment	9:00 p.m.

Thursday, June 14th

Authors' breakfast	7:45 a.m.
Technical Sessions	9:00-12:00 noon
Meeting, National Committee on Professional Development Programs	9:00 a.m.
Muriel's Room	12:00 noon
Luncheon, Presentation of Medals and Awards	12:30 p.m.
Students' Conference, final Session	2:30 p.m.
Meeting, Committee on Membership	2:30 p.m.
Association of Consulting Engineers, Annual General Meeting	2:30 p.m.
Local Plant Visits	2:30 p.m.
Association of Consulting Engineers—Annual Dinner	7:00 p.m.
Evening Free	

Friday, June 15th

Authors' breakfast	7:45 a.m.
Technical Sessions	9:00-12:00 noon
No Organized Luncheon	Noon
Technical Sessions	2:00-5:00 p.m.
Muriel's Room	6:30 p.m.
Annual Banquet, Special Speaker	7:30 p.m.
Annual Dance, Muriel's Room Open	10:00 p.m.

Saturday, June 16th

Extended Tours: SUGGESTIONS:

St. Lawrence Seaway.

Manicouagan Power Project, and Quebec Cartier Mine.

Quebec Iron & Titanium, Sorel.

(Continued from page 94)

Coming Events

nerican Institute of Electrical Engineers, Rubber and Plastics Conference, Akron, Ohio, April 9-10.

merican Society of Mechanical Engineers, American Institute of Electrical Engineers, Engineering Institute of Canada, Railroad Conference, Toronto, April 10-11.

eological Association of Canada, Canadian Institute of Mining and Metallurgy, Joint Annual Meeting, Ottawa, April 23-25.

merican Society of Mechanical Engineers, Maintenance and Plant Engineering Conference, New Orleans, May 7-8.

merican Mining Congress, Coal Convention, Pittsburg, May 7-9.

stitute of Radio Engineers, American Institute of Electrical Engineers, Electronic Components Conference, Washington, D.C., May 8-10.

echnical Association of the Pulp and Paper Industry, 13th Coating Conference, Cincinnati, May 15-16.

hemical Institute of Canada, Canadian Chemical Conference and Exhibition, Edmonton, May 27-30.

anadian Aeronautical Institute, Annual General Meeting, Montreal, May 28-29.

anadian Nuclear Association, Annual Meeting and Conference, Ottawa, May 28-30.

merican Society of Mechanical Engineers, Summer Annual Meeting, Quebec City, June 10-14.

ngineering Institute of Canada, 76th Annual General Meeting, Montreal, June 12-15. EIC

REMEMBER!

It's to your own

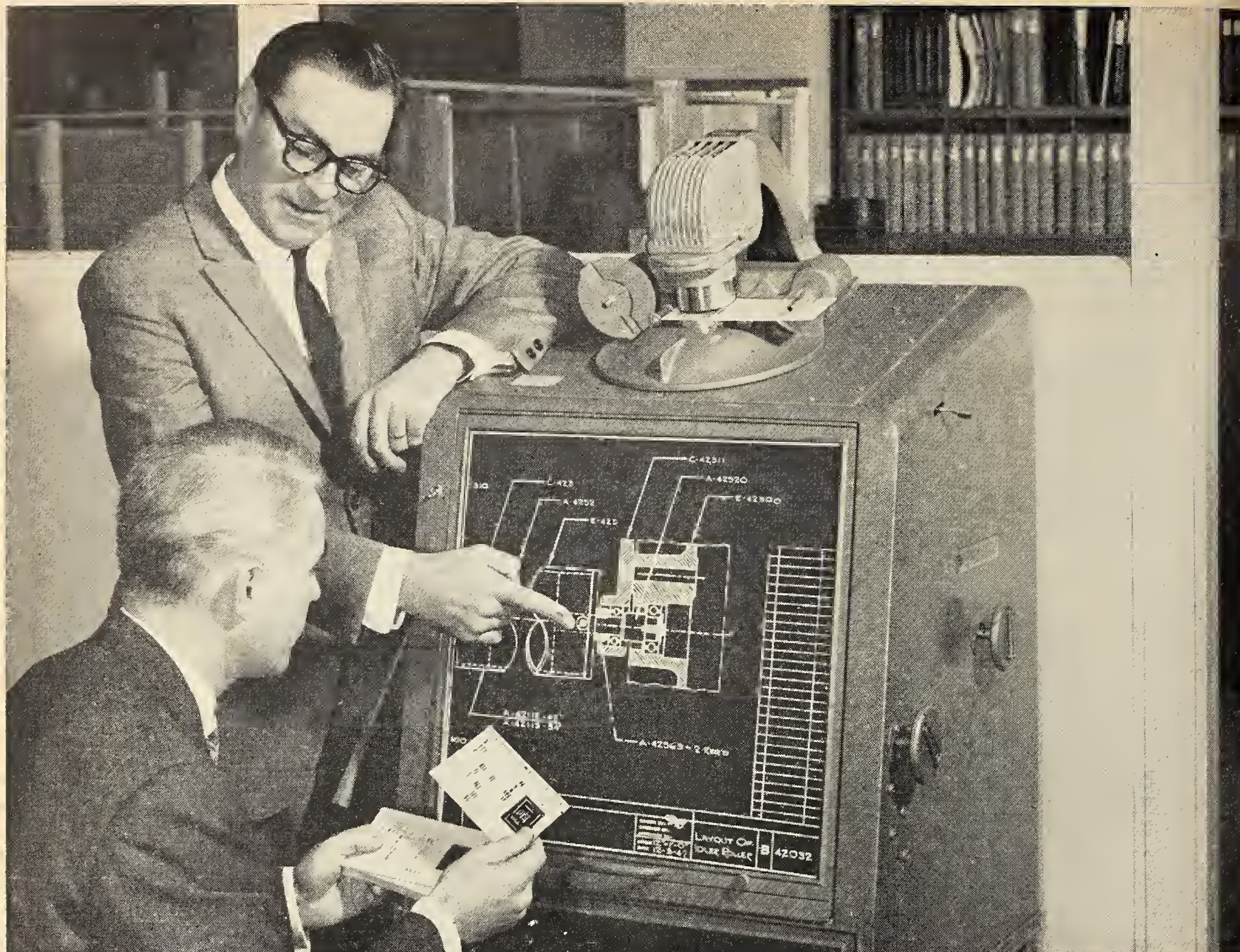
ADVANTAGE

to use

M.E.I.C. A.M.E.I.C. S.E.I.C.

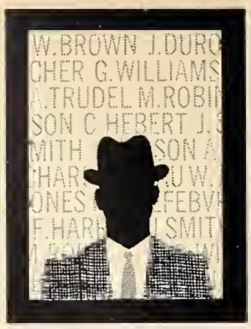
in all

your correspondence



It's all there, every detail sharp and clear, in RECORDAK precision 35mm microfilm imag

Personals



Peter Kupa, M.E.I.C. (Queen's '45) has been appointed Supervisor of the Polymer Corporation's Butyl Plant. Mr. Kupa, formerly the Assistant Supervisor, has already assumed his duties. Mr. Kupa joined Polymer in 1945. After serving in Production Control, he became senior engineer in the Styrene Unit in 1959, and two years later moved to the Production Division as assistant supervisor in the butyl plant.

Arnold H. Boehm, M.E.I.C. (Univ. of Prague '32) has joined the staff of Surveyer, Nenniger & Chenevert, Consulting Engineers of Montreal, as senior steel mill specialist. Mr. Boehm, who has wide experience in the steel industry, was formerly chief engineer and senior planning engineer of the Montreal Works of the Steel Company of Canada Limited.

Per Hall, M.E.I.C. (Royal Tech. College, Copenhagen '35), **Armand Couture,** M.E.I.C. (Univ. Laval '53) and **E. Van Walsum,** M.E.I.C. (Delft. '52) have formed the firm of Per Hall & Associates, with offices in Montreal. Mr. Hall has been responsible for numerous engineering projects in Denmark, Sweden and England. He has been in Canada since 1940, and in the services of the Aluminum Company of Canada, and The Foundation Companies. Mr. Couture held the position of Assistant Division Engineer, Traffic and Transportation with FENCO, and Mr. Van Walsum the position of Project Engineer also with FENCO, before joining the new firm.

John M. Dyke, M.E.I.C. (Toronto '43) has been appointed chief engineer of the boiler division at Dominion Bridge. Mr. Dyke joined the boiler design department in 1956 following wide engineering and sales experience in the combustion field.

Andrew Chmielenski, M.E.I.C. (Warsaw Univ. '34) has been elected president of Foundation of Canada Engineering Corporation Limited (FENCO). Mr. Chmielenski joined Foundation in 1952 and two years later was transformed to FENCO when that organization was formed as a separate member of the Foundation group. In 1957, he became FENCO's Division Engineer, Marine Structures. He became Vice-President of FENCO in 1960. In his new post, he will continue to make his headquarters in Montreal.

Trevor B. Davey, M.E.I.C. (Man. '53, McGill '57) has been appointed Associate Professor and Chairman of the Department of Mechanical Engineering at Sacramento State College, Sacramento, Calif.

E. J. (Ted) Beauchamp, M.E.I.C. (Sas '55) has recently accepted the positio of Building Engineer with the City o Oshawa. He was previously employe as a building enginer with the Depar ment of Buildings and Developmen Toronto.

Ronald C. Clough, M.E.I.C. has been ap pointed representative to British Co lumbia and Alberta for the Canadia Welding Bureau. Mr. Clough has ha several years experience as a consul ant specializing in welded design, bot structural and mechanical.

H. A. Cann, M.E.I.C. (Manitoba '36 formerly Western sales manager, Me chanical Products, Winnipeg, of th Dominion Rubber Company, has bee appointed general sales manager, Me chanical Good Division with head quarters in Montreal.

Harry Copping, M.E.I.C. (Leeds Coll. o Tech' 30) Managing Director and Pres dent of E.C.C. Canada Ltd. has bee appointed Ontario Representative on th Council of the Institute of Electric Engineers in London, England. He re places R. P. Horlock, who has bee transferred to the head office of A.E. Ltd., London, England. Mr. Coppin previously was Chairman of the Elec trical Section of the Engineering Institut of Canada in Toronto.

CONFERENCE

Some Aspects of Friction and Wear In Mechanical Engineering

JUNE 20, 1962: *Wear-Railway Rolling Stock Components*
W. H. Cyr, C.N.R., Montreal

Modern Developments in Friction and Wear Research
C. A. Brockley, U.B.C.

An Introduction to Rail Wear and Rail Lubrication Problems
K. R. Kilburn, Quebec North Shore & Labrador Railway, Sept-Iles

Discussion

JUNE 21, 1962: *The Frictional Mechanism of Rolling and Sliding Over Wood*
D. Atack, W. D. May, Pulp & Paper Research Institute of Canada

An Outline of the Mechanism of Sliding and Rolling Friction of Rigid Spheres and Cylinders Over Wood, and a discussion of their Role in the Wood-grinding Process

Discussion

News of the Branches

Baie Comeau

G. W. Scott, M.E.I.C.
Correspondent

As a supplement to their visit to Port Cartier last summer, Branch members held a film evening and discussion on February 15. R. B. Magahay, general manager of Foley Brothers (Canada) Ltd., introduced by L. A. G. Tellier, Branch Chairman, was the guest speaker. Formerly project manager of Pitts-Foley, the firm created for the construction of the Quebec Cartier Railroad, Mr. Magahay showed two films which paid tribute to the varied engineering problems involved in mining, processing and shipping iron ore.

The first film, entitled "Railroad to the North", covered the construction of the 194 mile Quebec Cartier Railroad which carries 12,500-ton capacity trains from the ore concentrator plant at Lac Jeannine to Port Cartier. A vivid impression of the varied terrain and the mammoth construction problems associated with this railroad was provided by the film taken during the construction of that $65 million project.

The route for the railroad was surveyed initially by areo-photographic methods. The original estimated excavation of 10 million cubic yards was exceeded by 8 million yards, and the construction program to meet this additional requirement was met by the provision of extra equipment, and working through the winter of 1959-60.

The second film entitled "Horizons North" was made by the Erie Mining Company, and showed the recently established 10 million ton capacity taconite processing plant at Hoyt Lakes in the Mesabi Range iron ore deposits in Northern Minnesota. Until mid-twentieth century, the conversion of taconite, containing 27% iron, into a commercially usable form of ore was not known to be economic and the Erie Mining Company spent $20 million on development work before starting the Hoyt Lakes project in 1953. The film showed the crushing, grinding and separating machinery required to reduce the ore from lumps as mined, to the eventual separation at pass 200 mesh, and the formation of pellets at 66% iron content suitable for blast furnace reduction.

A question and answer period followed the showing of each film. Mr. Magahay was thanked by Ian Sewell.

Belleville

A. F. G. Tooth, M.E.I.C.
Correspondent

Sid Sillitoe, engineer at Northern Electric, and a member of the Belleville transit commission, was the guest speaker at the Branch's February 12 meeting. Mr. Sillitoe reported on conditions in Belleville which led to the city taking over the transit system and on the problems the commission is confronted with in providing a satisfactory service.

On January 23, Dr. B. G. Ballard, President of the Engineering Institute of Canada, accompanied by Mrs. Ballard, the Secretary of the Institute, G. T. Page, and L. F. Mason-Tulby, visited the Branch for the President's banquet and Ladies' Night. Dr. Ballard spoke briefly on the problems of Confederation, and followed this by a most interesting talk on the role of the engineer today, his responsibilities to the economy and to the well-being of the world, his community and country.

Cape Breton

Lloyd Boutilier, M.E.I.C.
Correspondent

C. W. Hodgson, M.E.I.C., an associate in the firm of Ewbank, Tupper and Associates, was the guest speaker at the Branch's meeting held January 26. Mr. Hodgson was introduced by W. A. MacDonald, Manager, Seaboard Power Corporation. The title of Mr. Hodgson's talk was, "Modern Thermal Station Design and Related Operating Problems". In his talk, he dealt with the efficiency of thermal plants and the factors affecting their layout, including a review of the operational problems encountered with large layouts. He also described the control equipment used in thermal stations, feed water treatment and trends in future design. He emphasized the importance of controlling the starting temperature, so as not to cause undue stresses. He mentioned the speed control which necessitates the use of intercept valves to control the reheat. He said the furnace explosions occur when using either gas, old or pulverized coal. Usually, these occur when lighting takes place, or, under operation at light loads in pulverized fuel boilers. The unit control room takes over after starting operations are carried out on the floor. Manual operation is required to operate some of the valves, and to perform other tasks. Mr. Hodgson compared the costs of a thermal plant with those of a hydro plant, concluding that where hydro capital outlay is less, hydro is less expensive.

G. Naish thanked Mr. Hodgson on behalf of the 49 members present.

Cornwall

Fred R. Warner, M.E.I.C.
Correspondent

On February 15, the Branch held a meeting at the Parkway Hotel. Speakers included George van Beek, chief engineer at Courtaulds (Canada) Ltd., Charles Adams Jr., assistant city engineer, Kenneth Barnard, sales representative of Carrier Corporation and Edgar A. Cross, Vice-President of the Engineering Institute of Canada.

Mr. Cross reviewed past activities of the Institute and outlined plans for 1962. Mr. Van Beek, recently returned from a business trip in the European Common Market area and South Africa, gave a revealing picture of industrial developments in these countries. He compared engineering methods used with those in Canada. He mentioned that while efficiency is increasing in industry, costs are also mounting.

Impressions of a recent tour through Yugoslavia highlighted Mr. Barnard's address. He said that many new apartment buildings are being constructed in the cities. He commented that while costs for necessities were relatively low, luxury items were much more expensive.

Plans for the installation of the interceptor sewage main which will run parallel to Water Street, Cornwall, were outlined by Charles Adams Jr. He reviewed some of the technical details involved and mentioned the areas to be served by the main.

(Continued on page 155)

MESSAGE FROM THE PRESIDENT

ALLOCUTION DU PRÉSIDENT

Nineteen hundred and sixty-two heralds the 75th year of service of The Engineering Institute of Canada. We celebrate it with pride, and it will serve to remind us of the dedication and loyalty of our many members throughout the years, and of the continuing loyalty of our present membership. It will inspire us to even greater effort and to meet the challenge of the future.

We have a solid record of achievement. Our Institute is enjoying a continuing growth in membership, our technical program is improving each year, and our Branches are becoming increasingly active. We are playing a greater part in the affairs of the nation, and our members are serving on a growing number of national committees. This year we shall endeavour to achieve a unified profession which will be of even greater benefit to Canadian engineers and to the Canadian public. We have an Institute in which we can take pride.

Nevertheless, we have problems which require immediate attention. We must provide an increasing service for our members, and it is becoming more and more important that provision be made for suitable representation from all parts of the country to meet simultaneously. Studies to achieve a practical solution are now in progress, and there are encouraging prospects.

Our financial operation is not as favourable as could be desired. We shall operate at a deficit in the present year, and while we still have a substantial reserve, we must strive to balance our budget. Council has addressed itself to this problem. Expenses have been pared, and action has been taken to increase revenue.

I have been greatly impressed by the effort that our Councillors, Officers, Committee members and Headquarters staff have devoted to the Institute, and to them we owe a debt of gratitude. With their help, I have confidence that our problems will be solved and that our service will continue to improve. As I retire from the high office with which you have entrusted me, I do so with deep gratitude to all those members who have co-operated so generously, and who have given me every support. It has been an honour to serve you.

B. G. Ballard.

B. G. BALLARD, HON. M.E.I.C.
President, 1961-1962

Mil neuf cent soixante-deux marque les 75 ans de service de l'Institut canadien des ingénieurs. Nous célébrerons cet anniversaire avec fierté, et il nous permettra d'évoquer le dévouement et la fidélité des nombreux membres que l'Institut a comptés au cours des années, ainsi qui la fidélité de nos membres actuels qui continue cette tradition. Il nous engagera à faire des efforts encore plus grands et à faire front à toute situation future.

Nous avons de nombreuses réalisations à notre actif. Le nombre des membres de notre Institut augmente continuellement, notre programme technique s'améliore d'année en année et nos régionales connaissent une activité croissante. Nous jouons un rôle de plus en plus important dans les affaires de la nation et le nombre des comités nationaux dont nos membres font partie est en augmentation. Cette année, nous nous efforcerons de réaliser l'unité de la profession, ce qui sera encore plus avantageux pour les ingénieurs canadiens, et pour les Canadiens en général. Nous pouvons être fiers de notre Institut.

Nous nous trouvons néanmoins devant des problèmes qui exigent une solution immédiate. Nous devons assurer un service croissant à nos membres, et il est de plus en plus important de prendre des mesures pour réunir simultanément un nombre convenable de représentants de toutes les parties du pays. Les études que nous faisons pour trouver une solution pratique à ce problème progressent d'une façon satisfaisante, et les perspectives sont encourageantes.

Notre situation financière n'est pas aussi favorable que nous le souhaiterions. Nous prévoyons un déficit pour 1962, et bien que nous disposions toujours d'une réserve importante, nous devons nous efforcer d'équilibrer notre budget. Le conseil s'est attaqué à ce problème. Les dépenses ont été réduites, et des mesures ont été prises pour augmenter les recettes.

J'ai été très impressionné par les efforts accomplis par les conseillers, les directeurs, les membres des comités et le personnel du Centre, au service de l'Institut et nous avons envers eux une dette de reconnaissance. Avec leur aide, j'ai confiance que nous saurons trouver une solution à nos problèmes, et que notre service continuera à s'améliorer. En quittant la haute fonction que vous m'aviez confiée, j'exprime ma profonde gratitude à tous les membres qui ont si généreusement collaboré et qui m'ont accordé tout leur appui. Je considère comme un honneur d'avoir pu vous servir.

B. G. Ballard.

B. G. BALLARD, membre honoraire I.C.I.
Président pour 1961-1962

THE ENGINEERING INSTITUTE OF CANADA

annual report

for the year ended December 31 1961

REPORT OF COUNCIL

YOUR INSTITUTE IN 1961

Nineteen hundred and sixty-one was another year of continued great accomplishment for the Engineering Institute of Canada. Noteworthy were the Regional Technical Conferences, the Technical Program of the Annual Meeting, the expansion of the Committee on Technical Operations, and the improved publications services. Unfortunately all Branches have not yet taken advantage of all opportunities for improvement of their technical programs. This rapid growth naturally is accompanied by problems, notably in the areas of member communications and in finances.

Major targets for continuing concentrated effort during the year were: the highest possible quality of technical programs; the improvement of branch operations; growth of the membership. Literally hundreds of members are involved directly in the work of the Committee on Technical Operations and the Committee on Branch Operations. Every member should consider himself an active worker on the Committee on Membership.

ACTIVITIES OF THE PRESIDENT AND THE VICE-PRESIDENTS

Retiring President Dr. George McK. Dick and incoming President Dr. B. G. Ballard visited almost every Branch and Section. They also represented the Institute at many important meetings of sister societies.

In line with the new policy of assigning greater responsibilities to Vice-Presidents, and increasing the number of Vice-Presidents in 1961, all eight Vice-Presidents visited the Branches in their areas. These visits were separate from the Presidential visits and contributed greatly to improved communications on a two-way basis.

ADMINISTRATION

The Executive Committee assumed more of the administrative duties, thus allowing the Council to concentrate on policy to an increased extent.

The By-Laws were amended to bring them into line with today's needs. The new membership class of Fellow was created, and the designation of Junior Member was changed to Associate Member.

Tied in with each regional technical conference was a regional conference of branch officers. This new activity permits more adequate discussion of details between Branch Officers and Headquarters staff.

The committees and representatives appointed by Council made important contributions to the efficiency of the Institute's operations. Not only did they study proposals which were referred to them by Council, but each kept in touch with situations and attitudes within its terms of reference and, when necessary, recommended action.

Detailed reports of these committees and representatives follow. They are the detailed story of your Institute's progress.

The Headquarters staff was consolidated, with particular attention being paid to the expansion and reorganization of the advertising sales staff. This included the appointment of sales representatives in the United States, the United Kingdom, and continental Europe. It is expected that considerable additional advertising revenue will be forthcoming from these areas.

ANNUAL AND REGIONAL MEETINGS

The Annual General and Professional Meeting held in 1961 at Vancouver was an unqualified success. A enthusiastic local committee was responsible for the high attendance. The technical program, arranged by the Committee on Technical Operations, was one of the best in the history of the Institute.

Following is the schedule of future Annual Meetings.

1962 Montreal June 12-June 15 Queen Elizabeth
1963 Quebec May 22-May 24 Chateau Frontenac
1964 Banff May 27-May 29 Banff Springs
1965 Toronto May 26-May 28 Royal York
1966 Winnipeg May 25-May 27 Royal Alexandra
1967 Montreal May 31-June 2 Queen Elizabeth
1968 Halifax

Regional meetings held during the year were: Third Southern Ontario Regional Technical Conference, Niagara Falls; Northern Ontario Regional Technical Conference, North Bay; Eastern Quebec Regional Technical Conference, Quebec City. Joint meetings included: ASME-EIC Hydraulic Conference, Montreal; Production Engineering Conference, Toronto; International Heat Transfer Conference, Boulder, Colo.; Canadian Soil Mechanics Conference, Montreal.

These well-attended meetings broaden the technical activities of the Institute by making it possible for larger numbers of members to attend a major meeting each year.

INTERNATIONAL CO-OPERATION

Close work again was done with the Canadian Aeronautical Institute, the Canadian Institute of Min-

ıg and Metallurgy, the Chemical Institute of Canada. 'his co-operation included important government-ponsored and inter-society projects.

Regular and extremely cordial relations were mainıined with the Institutions in the United Kingdom, ther Commonwealth Societies, the founder Societies in ıc United States, the representative national organizaons in Europe, the Far East and Latin America. 'hese contacts were in addition to the formal meetıgs between representatives of the member societies f such international organizations as UPADI and ıe Conference of Engineering Societies of the British 'ommonwealth.

These frequent exchanges of information and asstance have proved invaluable to the Canadian enineering profession.

The co-operative agreements between the Engineerıg Institute of Canada and the Institution of Civil ngineers, the Institution of Electrical Engineers and ıe Institution of Mechanical Engineers of Great ritain provide members of any one of the participatıg bodies with the opportunity for participating in ıe technical activities while in the country of the ost body, on payment of a nominal fee.

On the invitation of your Institute, the Conference f Engineering Institutions of the British Commonealth will be held in Canada in September, 1962. lans are being developed to make an outstanding sucss of this important conference.

ONFEDERATION

The Engineers Confederation Commission presented s final report to the C.C.P.E. and E.I.C. at their ınual meetings in the summer of 1961. The E.I.C. ouncil requested the Executive Committee to study ıd recommend regarding the report, and to consult ith C.C.P.E.

The Executive Committee appointed two sub-comıittees to study the report, including a review of its ıancial implications. After a joint meeting with the .C.P.E. Executive Committee in July, the E.I.C. pubshed the report in full in the September issue of the ngineering Journal.

The President asked every Councillor, Branch and ıdividual member to read the report and to send im their option. Many comments were received, and ıch of these was carefully reviewed and considered y the Executive Committee.

It became apparent to the Executive Committee ıd Council that there were certain aspects of the port which required further discussion and clarificaon with C.C.P.E. Council agreed with this view and ıthorized the Executive Committee to meet with the C.C.P.E. Executive Committee for this purpose. The joint meeting was held in Montreal on December 15 and at the close of the year the matters under review were still under consideration.

ENGINEERING EDUCATION

The second national meeting of the Canadian Conference on Education was held in Montreal in February, 1962. The Institute was engaged actively in this significant activity.

More than seventy deans and professors of engineering from every faculty of engineering in Canada attended the 1961 E.I.C. Conference on Engineering Education. This two-day meeting was held in Montreal in June, during the Conferences of Learned Societies.

The Institute maintained its close and effective relationship with universities, appropriate agencies of the federal governments, and the Canadian Education Association.

GOVERNMENT LIAISON

The E.I.C. maintained its close relationship with the Federal Government. This involved working cooperatively with many agencies and departments on a day-to-day basis in the interests of Canadian engieering. These would be referred to the Institute either directly or by virtue of the Institute's membership on committees and boards established by the government.

HONOURS, AWARDS, MEDALS AND PRIZES

Awards presented during 1961 were:

Honorary Memberhips
Robert John Beaumont
Albert Edward Berry
Robert MacDonald Hardy
Hubert Ryerson Sills
Kenneth Franklin Tupper

Leonard Medal
John A. Hall

Duggan Medal and Prize
Stanley Dale Lash
Brian B. Hope

Robert W. Angus Medal
John Bemister Bryce

Sir John Kennedy Medal
Hubert Ryerson Sills

Julian C. Smith Medal
Arthur Duperon

Gzowski Medal
Carson Howard Templeton

R. R. Ross Medal
Lindsay Mansur Hovey

Plummer Medal
Robert Norman Boyd
Vladimir Joseph Bakanowski

John B. Galbraith Prize
Roger Hugh Wilkins

EMPLOYMENT SERVICE

Yearly Report
1961

	Atlantic	Central	Prairies	West Coast	USA	Foreign	Total
'UATIONS VACANT							
ssified Ads.	40	385	58	36	9	12	540
play Ads	4	76	8	18	9	—	115
plies to Ads	63	669	112	12	41	14	911
'UATIONS WANTED							
ssified Ads.	51	331	66	11	10	14	483
plies to Ads.	15	710	65	22	34	6	852

SITORS TO THE OFFICE — Employers 77 — Employees 814

LIBRARY SERVICE

Increased use made of the library by members from all parts of Canada as is shown in the statistics which follow.

Part of this increase is attributed to the publication each month of a list of the additions made to the library's collection. In addition to the Library Notes in the Engineering Journal the distribution began early last year of a mimeographed list. By the end of the year this list was being mailed regularly to 560 members, with new names being added daily.

Library Statistics 1961

	1960	1961	Increase
Borrowers registered	625	923	47%
Requests			
Letter	1817	933	
Telephone	2887	3419	
In Person	2656	3890	
Total	7360	8242	12%
Circulation			
Books	2557	3034	
Periodicals	1122	1285	
Pamphlets	186	208	
Total	3865	4527	17%
Loans to other libraries	561	814	45%
Loans from other libraries	63	99	55%
Parcels sent to out-of-town members	473	679	45%
Bibliographies compiled	23	42	82%
Books added to collection			
Donation	400	532	
Bought	54	82	
Total	454	614	35%
Total Value of Books Received	$4307	$5430	26%

MEMBERSHIP STATISTICS

	1960	1961
Hon. M.E.I.C.	41	45
Life Members	703	749
M.E.I.C.	8194	12117
A.M.E.I.C.	5575	4349
S.E.I.C.	6966	5279
Affiliates	57	62
Total	21,536	22,601

PROFESSIONAL DEVELOPMENT

The Institute was represented at the Annual Meeting of the Engineers Council for Professional Development as well as at the meetings of the Executive Committee and the Council. A further outline of the Institute's participation appears later in this Annual Report. An increasing interest in local Professional Development courses was shown at Branch level in many parts of Canada. This is co-ordinated by the Institute's national Committee on Professional Development Programs.

PUBLICATIONS

An extremely busy year for the Publications Committee was created by expanded and more-detailed terms of reference.

Its major effort was to ensure that the characteristics of the Institute's publications fulfull the needs of the members and meet the objectives of the Institute.

Much work and study was directed towards "Transactions of the E.I.C." Serious investigations were undertaken to determine the advisability and feasibility of expanding the value of Transactions while making it more financially attractive from the administrative point of view. "Transactions" is now an accepted medium in which Canadian engineers publish the results of their research.

As the result of enthusiastic demand from recipients of previous issues the fifth edition of "Engineering Careers in Canada" was distributed in December on a self-supporting basis.

TECHNICAL OPERATIONS

National—The Committee on Technical Operations and its Technical Division Committees now involve the active participation of more than 250 members representing every Branch of the Institute.

It is C.T.O. which provides the technical backbone of the Annual General Meeting, of Regional Technical Conferences, of the Journal and Transactions.

In addition, based on C.T.O. recommendations, the technical activities of the Institute are extended by its special representatives to special projects of many other technical societies, government agencies and educational activities.

To absorb the full story of the work of C.T.O., one must read every report which follows.

International—The Institute actively participates in the activities of international technical organizations. Included in these international activities are participation in the work of the ASME Committee on Air Pollution Controls, the Column Research Council, the International Association for Bridge & Structural Engineering, the International Federation of Chemical Engineers, the International Electrotechnical Commission, the Society of Technical Writers and Publishers, and the Inter-Society Management Engineering Conference.

VOCATIONAL INFORMATION

Many Branches performed their excellent work in this field, consisting mainly of speaking visits to junior colleges and secondary schools, and assistance to their staffs.

Headquarters handled many inquiries which usually were in the form of requests for literature. Some interviews were held. Many sample copies of the Engineering Journal were distributed.

The Institute co-operated with other national professional and technical bodies in sponsoring the Canadian Science Fairs. This co-ordinates the holding of science fairs in many parts of Canada.

WIVES ORGANIZATIONS

The Institute is interested and assists engineers' wives associations, even though they are not an official activity of the E.I.C. The purpose of all groups is to welcome newcomers to their centres and to promote cordiality and friendship among the wives of the members of the Institute, and in many cases, among the wives of all members of the profession.

Respectfully submitted on behalf of the Council.

B. G. BALLARD, HON. M.E.I.C.
President

GARNET T. PAGE, M.E.I.C.
General Secretary

REPORT OF OFFICIAL AUDITORS

Statement of Revenue and Expenditure

Year ended December 31, 1961

REVENUE

EMBERSHIP FEES	$189,525
UBLICATIONS	384,847
NCOME FROM INVESTMENTS	12,108
ISCELLANEOUS	6,604
TOTAL REVENUE	593,084
EFICIT FOR THE YEAR	68,924
	$662,008

EXPENDITURE

ADMINISTRATIVE EXPENSES:		
Staff salaries and benefits	$149,584	
Travelling—secretariat	9,898	
Other, less recoveries, $1,362	44,418	
	203,900	
Deduct allocation of expenses to Publication expenses	51,706	$152,194
DIRECT SERVICE EXPENSES:		
Annual and regional meetings	6,720	
Branch rebates, stationery and achievement awards	35,305	
Committees	1,490	
Institute medals and prizes	640	
Employment service	6,168	
Engineering education	1,254	
International activities	1,743	
Library	19,427	
Memberships	3,176	
Official reception and hospitality	1,116	
Professional development	2,485	
Student affairs	7,283	
Travel and meeting expenses	8,377	
	95,184	
Deduct allocation of expenses (employment service and library) to Publication expenses	2,592	92,592
PUBLICATION EXPENSES:		
Staff salaries and benefits	43,542	
Commissions	17,528	
Printing and mailing	222,070	
Other	56,670	
	339,810	
Add:		
Administrative expense allocation	51,706	
Direct service expense allocation	2,592	394,108
BUILDING AND RENTAL EXPENSES		13,571
EXTRAORDINARY EXPENSES:		
Confederation	3,075	
Consultants' fees—data processing	929	
Loss on sale of investments	5,539	9,543
		$662,008

AUDITORS' REPORT

We have examined the balance sheet of The Engineering Institute of Canada as of December 31, 1961 and the statement of evenue and expenditure for the year ended on that date and have obtained all the information and explanations we have required. ur examination included a general review of the accounting procedures and such tests of accounting records and other supporting vidence as we considered necessary in the circumstances.

In our opinion, and according to the best of our information and the explanations given to us and as shown by the books the Institute, the accompanying balance sheet and statement of revenue and expenditure are properly drawn up so as to exhibit true and correct view of the state of the affairs of the Institute at December 31, 1961 and the results of its operations for the ear ended on that date, in accordance with generally accepted accounting principles applied on a basis consistent with that of the receding year.

PEAT, MARWICK, MITCHELL & CO.

Chartered Accountants

MONTREAL, P.Q., MARCH 1, 1962.

TREASURER'S REPORT

Balance Sheet

December 31, 1961

ASSETS

CURRENT ASSETS:		
Cash		$ 971
Accounts receivable, less allowance for doubtful accounts		33,608
Arrears of membership fees, estimated		6,500
Sundry advances and deposits		1,440
Miscellaneous supplies and prepaid expenses		13,351
		55,870
INVESTMENTS, AT COST:		
Securities (market value $216,079)	$219,447	
Less held for special funds	38,338	181,109
FIXED ASSETS, AT COST LESS AMOUNTS WRITTEN OFF:		
Land and building	36,000	
Furniture and equipment	24,450	
Library	1	60,451
ASSETS OF SPECIAL FUNDS:		
Equity in investments shown above		38,338
TOTAL ASSETS		335,768
DEFICIT:		
Surplus at beginning of year	5,221	
Add:		
Transfer from reserve for contingencies	25,000	
Library deposits written off	3,798	
	34,019	
Deduct deficit for the year	68,924	
Deficit at end of year		34,905
		$370,673

LIABILITIES

CURRENT LIABILITIES:		
Bank overdraft—secured		$ 27,452
Accounts payable and accrued charges		67,881
Fees paid in advance		3,561
		98,894
OTHER LIABILITIES:		
Life members' voluntary contributions	$ 7,340	
Other unexpended contributions for special purposes	8,869	16,209
RESERVES:		
Building	184,000	
Building maintenance	1,500	
Contingencies	4,500	
Publications	27,232	217,232
SPECIAL FUNDS:		
Memorial and prize funds	5,498	
Other trust funds	32,840	38,338
		$370,673

TREASURER'S REPORT

The operations of the Institute for 1961 resulted in a deficit of $68,924, which was due mainly to insufficient revenue to carry on membership operations, as the publications program is generally self-supporting.

Deficits for the years 1958 to 1960 totalling $93,555 had depleted the working capital to such an extent that it was necessary during 1961 to liquidate a portion of the Institute's investments. $93,299 was provided in this manner and the working capital was temporarily restored. However, the deficit for 1961 has again depleted the working capital, and it will again be necessary to liquidate investments unless membership fee revenue is increased. It is proposed to recommend to the membership a general increase in fees. In the meantime the deficit is financed by an overdraft at the bank, secured by investments owned by the Institute.

The Balance Sheet as at December 31, 1961, the Statement of Revenue and Expenditure for the year 1961 and the Auditor's Report are submitted herewith.

E. B. JUBIEN, M.I.E.C.

Treasurer.

REPORTS OF THE COMMITTEES

STANDING COMMITTEES

ADMISSIONS COMMITTEE

1. *Statistical Review*

During 1961, the Admissions Committee held seven regular meetings.
In all, the applications of 860 candidates were considered, including 58 Special Cases.

Admitted for Corporate Membership		228	
Admitted for Affiliate		8	
*Transferred from Junior to Member		573	
Transferred from Student to Member		2	
*Transferred from Student to Associate Member		18	
Transferred from Associate Member to Affiliate		1	
Transferred from Student to Affiliate		1	
Special Cases			
Referred to Board of Examiners	11		
Rejected	14		
Held for further investigation	33		
**Student Admissions		1578	2409
**Admissions and Transfers through Provincial Associations			
Admitted for Corporate Membership		94	
*Transferred from Junior to Member		119	
*Transferred from Student to Associate Member		30	
Student Admissions		9	252
			2,661

* Automatic transfers are not included in these figures.

** These figures are included for the sake of completeness, although these categories are not reviewed by the Admissions Committee.

The reason for the decrease in transfers as shown in this report, is due to the recent amendments to the By-laws, whereby Students are transferred to the grade of Associate Member in the first January after graduation—Associate Members are transferred to Members in the fifth year after graduation. (These transfers are automatic).

2. *Procedures*

(a) The procedures of the Admissions Committee were clarified, brought up to date, and submitted to Council for approval.

(b) The application form in the French language was put into use in 1961.

(c) Recommendations were made to Council, on request, concerning the following items: 1. Admissions of Members of the British Institutions. 2. Accreditation of Canadian Engineering Courses. 3. Acceptability of Engineering Physics Graduates. 4. E.C.P.D. Listing of Canadian Courses.

COMMITTEE MEMBERS:

Chairman: P. W. Gooch, Montreal
Vice-Chairman: W. Bruce, Montreal

Members: J. H. Budden, Montreal
W. H. Gauvin, Montreal
R. J. Harvey, Montreal

PETER GOOCH, M.E.I.C.
Chairman

COMMITTEE ON BRANCH OPERATIONS

The Committee on Branch Operations completed its analysis of the returns to the questionnaire which had been sent to the Branches late in 1960, and its comprehensive report was submitted to Council at its meeting of April 22nd, 1961. The report, which submitted 18 recommendations, was made available to all Branches of the Institute shortly thereafter.

The Committee has been active throughout the year, it having met in Vancouver at the time of the 1961 AGM on May 30th, when the meeting was a joint one with Branch Officers. It met again in Toronto on November 24th.

The Subcommittee on Branch By-Laws has been active and has almost completed work on the model Branch By-Laws, as well as studying suggested changes by several Branches.

During the year a substantial milestone was marked by the distribution of a number of Manuals on Branch Operations prepared by Headquarters.

The Committee assisted the Committee on Branch Achievement Awards by studying and submitting recommendations to that Committee on suitable criteria to be adopted for the George McKinstry Dick Branch Achievement Awards.

There is increasing evidence this Committee, as constituted in 1960, is able to contribute materially to those activities of E.I.C. in which the Branches are not vitally concerned.

COMMITTEE MEMBERS:

Vice-Chairman: J. R. Rettie, Winnipeg
Secretary: G. M. Boissonneault, Montreal
Members: F. M. Cazalet, Vancouver
Edgar A. Cross, Toronto
George Desjardins, Montreal
Roger Desjardins, Montreal
J. R. Eason, Arvida
R. H. Stevenson, Hamilton
C. L. Thompson, Toronto
G. F. Vail, Halifax

F. L. LAWTON, M.E.I.C.
Chairman

FINANCE COMMITTEE

During the year your Finance Committee met eleven times. At each meeting the monthly reports prepared by the Controller have been critically analyzed and the financial aspects of the operation of the Institute have been studied in the light of its revenue. The accounting system, which is now on an accrual basis, permits a more realistic evaluation on a continuing and comparative basis of its financial position.

These monthly reports include detailed and separate statements of revenues and expenditures in the fields of membership and publications. It is obvious from these statements that the deficit arising from an excess of expenditures over the revenues from membership fees account for the large share of the overall deficit incurred during 1961. The service performed for its members have been reviewed individually and critically. Some reduction in expenditure was affected while the quality of the services was not lowered. However, even if it were possible to reduce such expenditures by a fair percentage, it would still be necessary to increase the revenues from membership fees to avoid a recurring deficit. The net increase in revenue accruing from the normal increase in membership is not adequate to meet the current or projected costs of services to the membership. Your financ committee, therefore, saw fit to present a motion to Council to promote a general increase in fees. Council approved this unanimousl and a notice of change of by-laws will be presented at the Annual Meeting for approval and subsequent ballot of the membership.

Although the revenues from the publications of the Journal paid for the printing and distribution of Transactions and othe technical data, they did not show a surplus beyond the recovery of overhead allocated to its operation. The general business climat forecast for 1962 permits your Committee to expect again a balanced operation in this area with perhaps a surplus of revenues ove expenditures.

Some of our securities had to be sold to meet our cash requirements reducing thereby the assets of the Institute. It was fel necessary to draw on the reserves which had been built up for this purpose during the years when our publication activities permitte it. It appears likely that these procedures will need to be repeated in 1962 as the increase in membership fees, if voted for, will no be effective until 1963.

COMMITTEE MEMBERS:

Chairman: G. N. Martin, Montreal
Treasurer and
Vice-Chairman: E. B. Jubien, Montreal
Members: J. M. Breen, Montreal
J. H. Budden, Montreal
T. W. Eadie, Montreal
A. W. Howard, Montreal
F. L. Lawton, Montreal
G. R. Rinfret, Montreal
Leo Roy, Montreal
E. R. Smallhorn, Montreal
W. I. M. Turner, Montreal

G. N. MARTIN, M.E.I.C
Chairma

LEGISLATION COMMITTEE

No meetings of the Legislation Committee were held in 1961 and no matters have been referred to the committee. It is hope that a meeting of the committee can be held during the opening day of the Annual Meeting in Montreal and as a result of th meeting a report forwarded Council for consideration.

COMMITTEE MEMBERS:

Chairman: W. B. Pennock, Victoria
P. N. Bland, Vancouver
D. Cramer, Lethbridge
S. Barkwell, Winnipeg
W. R. Meredith, Ottawa

W. B. PENNOCK, M.E.I.C
Chairma

LIBRARY AND HOUSE COMMITTEE

Library

Council, meeting in Vancouver last May, gave approval in principle to the recommendations of last year's Committee to have E.I.C. members use the N.R.C. Library service and to discontinue the E.I.C. Library. The principal task of this year's Committee was the development of detailed proposals for implementing this decision. These were contained in a Second Report which was presented to Council in October. Discussion at this meeting revealed considerable controversy over the basic proposal. At the following meeting in February, the earlier basic policy decision was reversed and the E.I.C. Library will therefore continue in operation. Discussion of this issue has stimulated interest in the Library and has increased circulation.

The Committee also made a study, at the request of Council, on ways of operating the Library at reduced cost. This study revealed no significant avenues for increasing Library revenue, or for reducing operating cost without reducing service.

The major problems which confronted the Library a year ago remain unsolved. These comprise a two year backlog in cataloguin book acquisitions, lack of adequate space for reading room and bookshelves, and lack of capacity to cover in depth the multifol areas of knowledge of interest to today's engineers. The development of suitable solutions without a major increase in the Librar budget is a formidable task and will require careful study.

House

Headquarters staff are housed in the headquarters building on Mansfield Street and in a converted apartment nearby. Growt in recent years has led to serious overcrowding and consequent inefficiency. Several studies were made during the year of ways o improving the situation. The most satisfactory solutions appear to entail either the rental of additional space or the conversion of th auditorium to office use. No decision has yet been reached on this matter.

Major repairs are required to the mitoyen wall on the north side of the headquarters building. The financial liability for these epairs was discussed with the co-proprietor. Following failure to agree it was decided to appoint an arbitrator whose report is now waited.

OMMITTEE MEMBERS:

Chairman: R. N. Boyd, Montreal
Corresponding Members:
R. W. Underhill, Calgary
C. R. Elliott, St. John's, Nfld.

Members: J. Benoit, Montreal
O. R. Brummell, Montreal
L. J. Hammerschmidt, Montreal
W. C. M. Luscombe, Montreal

R. N. BOYD, M.E.I.C.
Chairman

COMMITTEE ON MEMBERSHIP

The most important event of the year in membership activity was the amendment to the By-Laws on eptember 1st, affecting the automatic transfer of both Students and Associate Members (formerly Juniors) higher grade. This created an unusually heavy amount of work in the Fall and early Winter in notifying ll concerned by letter, arranging and forwarding the revised billing, in co-operation wherever applicable ith the Provincial Associations. About 2000 Students and 2600 Associate Members were involved.

The national Committee on Membership continued its work during the year, inquiring into and recom- ending action to Council on different ways and means of promoting interest in membership, and improving s administration. Contact with the Branches was maintained through a series of circular letters on member- ip topics, issued through Headquarters about once a month. This will be continued.

Further steps were taken to make the administration of membership affairs bi-lingual. Literature, forms, c., have been translated and reprinted, making them available now in both languages. Routine correspondence ceived in French is answered in French, and form letters are despatched in French whenever it is believed that the recipient ould prefer it.

The new design of membership certificate was taken into use, and it was well received by those concerned. The improved ppearance of the E.I.C. certificate is expected to have a strong effect on enhancing the Institute's prestige. The special certificate r Life Members was in process of distribution to all known surviving senior members in that grade. It is expected that this job ill be completed during the winter.

The total enrolled membership at the close of 1961 stood at 22,601 which is a 5% increase over 1960. The detailed breakdown this figure is given in another section of this report.

OMMITTEE MEMBERS:

Chairman: E. D. Gray-Donald, Montreal
Members: Hugh C. Brown, Montreal
Gaetan Cote, Sherbrooke
C. Fisher, Winnipeg
Yvan Hardy, Montreal

C. Peter Jones, Vancouver
R. J. Kane, Montreal
Elsie G. MacGill, Toronto
W. A. Smith, Calgary
G. F. Vail, Halifax

E. D. GRAY-DONALD, M.E.I.C.
Chairman

PUBLICATIONS COMMITTEE

The Committee was influenced in the new work it undertook in 1961 mainly by three factors.

Council had approved the Committee's recommendations for "Objectives" and "Policies" for the Journal d Transactions which were documented to provide guidance to the many people concerned with these iblications. These are directed, of course, to fulfillment of the objectives of the Institute and particularly to cilitate the interchange of professional knowledge among the members and to encourage original research d the study, development and conservation of the resources of the Dominion. The Journal has the additional nction of providing a means of communication to members on Institute affairs.

Surveys conducted among readers and branch officers in 1960 and 1961 provided some guidance as to inions, interests, needs and desires of members. More prompt publication of papers and expansion of iblications to cover more fields of interest were indicated.

Increasing numbers of papers suitable for publication are becoming available through expanded annual neral meetings, regional technical conferences and higher calibre branch meetings. Also there is a rapidly increasing number of papers ing prepared in highly specialized fields for which suitable publication should be available through the Institute. With the increasing estige and more widespread recognition of the "Journal" and "Transactions" an increasing number of members are desirous of having eir papers published under the auspices of the Institute.

Guided by the foregoing, the Committee has given particular attention to three projects:

A study of the non-technical contents of the "Journal" to provide guidance to the Editor on the relative importance of the several lepartments" of the "Journal". The resulting recommendations were approved by Council.

A Guide to Authors of technical papers is being prepared to assist in the preparation of better papers, to facilitate publication, encourage readership and to stimulate the writing of papers.

A plan, which is being prepared for submission to Council, would provide for prompt distribution of Transactions-type papers interested members according to the members' fields of technical interest.

In 1961 there were sixty-seven technical papers published in the "Journal" and in "Transactions". Forty-six of the "Journal" apers came from annual general meetings of the Institute with the remaining twenty-one directly from members. Contrary to the inions held by some members, the "Journal" papers covered the many fields of interest roughly in proportion to the membership, cept in Mining for which more papers are needed.

Bridge and Structural	4		General	7
Chemical	4		Geotechnical	2
Civil	12		Hydro-Electric	6
Education	3		Management	6
Electrical	10		Mechanical	13
			Total	67

COMMITTEE MEMBERS:

Chairman: R. A. Phillips, Montreal
Vice-Chairman: B. O. Baker, Ottawa
Members:

Civil Engineering:	N. B. Hutcheon, Ottawa
Bridge and Structural Engineering:	J. S. Walsh, Montreal
Chemical Engineering:	W. H. Gauvin, Montreal
Electrical Engineering:	D. J. McDonald, Montreal
Geotechnical Engineering:	I. D. MacKenzie, Montreal
Hydro-Electric Engineering:	P. Duchastel, Quebec
Management Engineering:	W. Bruce, Montreal
Mechanical Engineering:	G. V. Meagher, Toronto
Mining and Metallurgical Eng.:	No appointee

R. A. PHILLIPS, M.E.I.C.
Chairman

COMMITTEE ON TECHNICAL OPERATIONS

The Committee on Technical Operations held one full meeting in Toronto, September 8, 1961. This was an organizational meeting. Most of the subsequent work was carried out by correspondence between the various division Chairmen with the main effort directed towards arranging the technical program of the 1962 Annual Meeting. Recognition and support was given to various other proposed regional technical conferences organized, as intended by the regions or Branches themselves.

Several of the Divisions also held meetings during the year. These include a meeting of the Mechanical Division during the 1961 Annual Meeting at Vancouver, and a meeting of the Geotechnical Division in November at Montreal.

C.T.O. experienced difficulty in obtaining or replacing Chairmen who were unable to continue. New appointments were required for the Mechanical Engineering Division, the Chemical Engineering Division and the Bridge and Structural Engineering Division. The lack of a mining engineer willing to assume the duties as Chairman of the Mining Engineering Division has forced a continued vacancy in this important position.

Organizational difficulties, particularly in the Chemical and Mining fields, indicate a need for all possible encouragement of co-operation between the E.I.C. and the Chemical Institute of Canada and the Canadian Institute of Mining and Metallurgy. These two organizations already have enthusiastic technical operations of their own, and there is little to be gained by having the E.I.C. compete. However, much is to be gained by active co-operation among these bodies and the corresponding Divisions of C.T.O.

C.T.O. is growing. Recently Council authorized the formation of a new division—The Communications, Electronics and Automation Division. Formation of two other divisions is under active consideration; Thermal Engineering Division and Welding Engineering Division. Those wishing to become active in these new divisions are requested to write to the General Secretary.

COMMITTEE MEMBERS:

Chairman: S. Sillitoe, Belleville
Technical Division Committee Chairmen:

Bridge and Structural Eng.:	A. M. Bain, Montreal
Chemical Engineering:	G. M. Govier, Edmonton
Civil Engineering:	R. M. Hardy, Edmonton
Electrical Engineering	A. J. Girdwood, Guelph
Engineering Education:	A. Porter, Toronto
Geotechnical Engineering:	R. F. Legget, Ottawa
Hydro-electric Engineering:	J. A. Thomas, Montreal
Management Engineering:	W. L. Hutchison, Toronto
Mechanical Engineering:	A. R. Edis, Montreal
Mining Engineering	No appointee

S. SILLITOE, M.E.I.C.
Chairman

SPECIAL COMMITTEES

BOARD OF EXAMINERS

The Board of Examiners held one meeting during 1961, at which twenty (20) candidates were considered. A suggested policy covering the work of E.I.C. Board of Examiners, presented by Mr. E. C. Luke, M.E.I.C., Membership Services Manager, was discussed and unanimously approved by the Board of Examiners with a minor revision. Subsequently this suggested policy was submitted to Council for consideration.

Four (4) candidates were referred to Council with recommendation for acceptance as Members after verifying their qualifications. One (1) candidate was recommended for the grade of Associate Member. It was also recommended that one (1) candidate be offered Affiliate grade membership. Four (4) candidates were referred to the Provincial Associations for completion of their qualifications. One (1) candidate was refused membership for failing to meet the requirements for admission. At the end of 1961 nine (9) candidates were still under consideration.

Professor Carlton Craig, a member of this Board, died on 24 December 1961.

COMMITTEE MEMBERS:

Chairman: R. Boucher, Montreal
Members: Y. DeGuise, Montreal
G. R. Garby, Montreal
A. Leclerc, Montreal

RAYMOND BOUCHER, M.E.I.C.
Chairman

BRANCH ACHIEVEMENT AWARDS COMMITTEE

The Geo. McKinstry Dick Branch Achievement Awards were authorized by the Executive Committee at its meeting of February 25th, 1961. At this time the Executive Committee decided to establish one Award for presentation annually to a large Branch and one to a small Branch, the Awards being described in the following terms:

"The Branch Achievement Award should take the form of a plaque, on which can be added each year the name of the recipient Branch.

A feature could be the free transportation of the Branch Chairman, or his nominee, to the Annual Meeting.

Branches would be judged on their overall Branch operations, membership growth, and technical activities.

The Selection Committee might well be the Chairman of the three committees concerned with Branch Operations, Membership and Technical Operations.

That the first award be made in 1961, that the arrangements for such an award be 'firmed up' as soon as possible, and that the award be called the 'George McKinstry Dick Branch Achievement Award'."

The Award Committee was officially constituted as the Chairman of CTO, the Chairman of C.B.O. and the Chairman of the Membership Committee.

It was agreed that the initial work involved in the study of criteria to be adopted in connection with the Awards should be undertaken by CBO following which the Branch Achievement Awards Selection Committee would finalize the criteria to be utilized.

The Committee adopted the following criteria:

1. Percentage increase in number of Branch corporate members for the administrative year.
2. Percentage increase in number of Branch Student members.
3. Percentage increase in number of technical meetings.
4. Percentage increase in number of technical papers of Branch origin whether presented at Branch meetings, Regional Conferences, Annual Meetings or submitted for Journal publication as well as those submitted for Institute awards by Associate Members.
5. Percentage turnout of members of Branch Executive to meetings of Branch Executive.
6. **For large Branches only** increase in number of technical Divisions, sub-divisions, or new Branches sponsored and professional development courses operated.
7. Percentage decrease in number of resignations and removals.

The weighting to be applied has been decided on as follows:

Small Branches

Elements 1, 3, 4, 5 and 7, equally weighted. Where there is a Student Branch within Branch territory, element 2 would be added and combined with element 1 using the average.

Large Branches

Elements 1, 3, 4, 5, 6 and 7, with equal weighting. Where there is a Student Branch within Branch territory, element 2 would apply in application it being combined with element 1 and an average taken.

It has further been decided that a Small Branch is to be considered as one having 100 members or less, with all the rest as Large Branches.

A suitable communication was prepared for dispatch to Branch Secretaries early in January advising them of the criteria adopted and asking for the necessary returns so that the Committee could evaluate the performance of the Branches and decide on the Awards.

COMMITTEE MEMBERS:

Chairman: F. L. Lawton, Montreal
Members: E. D. Gray-Donald, Montreal
S. Sillitoe, Belleville

F. L. LAWTON, M.E.I.C.
Chairman

COMMITTEE ON CO-OPERATIVE AGREEMENTS

Because of the discussions now in progress regarding Confederation the work of this Committee for the past year has been one mainly of study of existing agreements.

1. An analysis of the agreements now in force between the Institute and the Corporation of Professional Engineers and the Associations of Professional Engineers of Nova Scotia, Prince Edward Island, New Brunswick, Manitoba, Saskatchewan and Alberta was made and a report submitted to the President.
2. A review of the constitution and operations of the Engineers Joint Council was made and comments submitted to the President.
3. Some study was given to the operating agreements between the E.I.C. and The Institution of Civil Engineers, The Institution of Mechanical Engineers and The Institution of Electrical Engineers of Great Britain. Whereas no specific recommendations were made, the General Secretary was requested to discuss these agreements with the officers of the Institutions concerned on his trip to England which took place in February 1962, with a view to reaching a form of agreement that would better conform to existing conditions. There is nothing to report beyond the fact that such interviews took place and that the discussions, which were conducted on a most friendly basis, will continue.

COMMITTEE MEMBERS:

Chairman: E. D. Gray-Donald, Montreal
Members: F. L. Lawton, Montreal
Garnet T. Page, Montreal
S. Sillitoe, Belleville

E. D. GRAY-DONALD, M.E.I.C.
Chairman

THE INTERNATIONAL ASSOCIATION FOR THE EXCHANGE OF STUDENTS FOR TECHNICAL EXPERIENCE

As predicted late last year, sub-normal business conditions during the early months of 1961 had an adverse effect on Canadian industrial participation. The total dropped to the lowest point since 1955 and it was not possible to place more than 79 foreign students in jobs in Canada.

On the other hand, 33 Canadian engineering students took advantage of the opportunity to go abroad. This is the largest figure for Canadian student participation since we joined the association, and it is a gratifying result. More of our students are learning about the possibilities of IAESTE as word about it is spread around.

The Canadian Committee was one of those invited to report on problems related to IAESTE participation by students from countries outside of Europe. This was prepared and forwarded to the General Secretary in July.

Mr. A. W. Town, of Leeds University, visited Canada during the Summer as representative of the IAESTE Committee in Great Britain.

COMMITTEE MEMBERS:

Chairman: L. A. Duchastel, Montreal

Industrial Representatives:

D. B. Best, Montreal (Northern Electric Co.)
E. A. Clark, Montreal (Aluminum Co. of Canada)
J. M. Cape, Montreal (E. G. M. Cape & Co. Ltd.)
W. G. H. Holt, Montreal (Dominion Bridge Co. Ltd.)
G. E. Shaw, Montreal (Canadian Pacific Rlwys.)

Society Representatives:

D. Jones, Montreal (Canadian Pulp & Paper Association)
D. M. Morrell, Montreal (Canadian Chamber of Commerce)
C. Gerow, Montreal (Can. Inst. of Mining & Metallurgy)
F. L. Lawton, Montreal (Canadian Electrical Association)
T. H. G. Michael, Ottawa (Chemical Institute of Canada)
E. L. Mahoney, Ottawa (Canadian Construction Association)

University Representatives:

Bernard Marois, Montreal (McGill)
G. A. Wallace, Montreal (McGill)
M. Poupard, Montreal (Ecole Polytechnique)

Secretary: E. C. Luke (E.I.C. Headquarters)

L. A. DUCHASTEL, M.E.I.C.
Chairman

LIFE MEMBERS COMMITTEE

As in previous years, the Committee have been active in looking to the interest of the Young Engineer and in the study of matters pertaining to the welfare of the Institute as a whole.

One of the projects in which the Life Members have always been interested and to which contributions have been made each year is the attendance of student delegates at the Annual Meeting. This year, because of the increased travel distance, due to the fact that the Annual Meeting was held in Vancouver, our contribution for this purpose was increased by $500.00 making it $1000.00.

A contribution of $25.00 toward the cost of each of the Student's Prizes was also made in order to increase the value of these prizes to $50.00.

At the request of the Library and House Committee, a sum of up to $500.00 was made available to the Library Fund for the purchase of duplicate reference books.

In view of the importance to the Institute of the question of Confederation, and of the forthcoming discussion of this question at the Annual Meeting, the Committee decided to send as representatives to the Meeting, Dr. L. Austin Wright and Dr. Irving R. Tait. These Members have been in close touch with the Confederation Movement since its inception and were considered to be most capable of expressing the views of the Committee in this matter.

When the report of the Commission on Confederation was made available to the Members of the Institute, a sub-committee was appointed to study this report. As a result of this study and the discussion following, the Life Members Committee made a submission to the President of the Institute strongly recommending the rejection of the Commission's proposals. The Life Members Committee are convinced that the adoption of these proposals would result in the virtual abandonment of the Engineering Institute of Canada and all that it has stood for in the life of the profession.

Another matter that has been of serious concern to the Committee is the proposal that was made to the Council of the Institute to abandon the Institute's Library. In view of the valuable service that the library has rendered to the members of the Institute over the years, the Committee regards this as a retrograde step, and so advised the President and Council.

Dr. L. Austin Wright, who has made such a valuable contribution to the Committee as Chairman, resigned toward the end of the year because his change of address to Sidney, B.C. made it impossible for him to carry on. The Committee were very sorry to lose his valuable services and accepted his resignation with regret. Mr. C. Kirkland McLeod was elected Chairman in his place.

The number of Life Members at the end of the year 1961 was 749. The financial statement is attached.

J. A. FREELAND, M.E.I.C.
Secretary

LIFE MEMBERS' VOLUNTARY CONTRIBUTIONS

REVENUE AND EXPENDITURE

Balance, December 31, 1960		$ 8,522.18
Revenue		
Contributions received	$1,643.28	
3% Interest credited to account	234.42	1,877.70
		10,399.88
Expenditure		
June 29, 1961—Meeting expenses, 1960/61	60.95	
July 28, 1961—Dr. L. A. Wright—Attendance at Annual Meeting	662.55	
Dr. I. R. Tait—Attendance at Annual Meeting	617.25	
Aug. 31, 1961—Contribution to 1961 Students' Conference	1000.00	
Sept. 12, 1961—Stenographic expenses of Chairman and Secretary	100.00	
Dec. 31, 1961—Meeting expenses	62.91	
Preparing and mailing letters by E.I.C. Headquarters	56.22	3,059.88
Balance December 31, 1961		7,340.00

NOMINATING COMMITTEE

Amherst, J. N. Ritchie
Baie Comeau, Gordon Mikkelborg
Belleville, G. Bradford
Border Cities, M. Armstrong
Brampton, K. Giddings
Brockville, J. R. Eastwood
Calgary, R. T. Hollies
Cape Breton, Harold M. Aspinall
Central British Columbia, J. W. Nelson
Chalk River, A. J. Summach
Comerbrook, A. W. Curren
Cornwall, L. H. Snelgrove
Eastern Townships, E. T. Harbert
Edmonton, S. R. Sinclair
Fredericton, Otis Logue
Halifax, Gilbert F. Vail
Hamilton, P. J. McNally
Huronia, H. C. Bates
Kingston, W M. Campbell
Kitchener, W. Bobbie
Kootenay, G. W. Downie
Lakehead, V. B. Cook
Lethbridge, C. S. Clendening
London, W. Ayearst
Lower St. Lawrence, No Nominee
Moncton, J. F. Callaghan
Montreal, C. E. Frost
Newfoundland, G. E. Knight
Niagara Peninsula, G. Cline
Nippissing & Upper Ottawa, C. A. Hellstrom
North Eastern Ont, No Nominee
Northern New Brunswick, R. W. Rankine
North Nova Scotia, John E. Clarke
North Shore Lower St. Lawrence, R. F. Dee
Oakville, D. A. Sinclair
Ottawa, H. Chaput
Peterborough, D. A. Lamont
Port Credit, A. E. Cooke
Port Hope, J. S. Coopman
Prince Edward Island, J. D. MacDonald
Quebec, L. P. Bonneau
Richmond Hill, D. C. McMillan
Saguenay, D. L. Aker
Saint John, J. B. Eldridge
St. Maurice Valley, J. P. Woods
Sarnia, Ralph F. Routledge
Saskatchewan, W. B. Clipsham
Sault Ste. Marie, Frank MacKay
Sudbury, F. A. Orange
Toronto, E. R. Davis
Vancouver, Percy N. Bland
Vancouver Island, Cdr. P. F. Fairfull
Whitby, No Nominee
Winnipeg, J. B. Striowski
Yukon, E. Kellett

Chairman: E. D. GRAY-DONALD

PRIZES AND AWARDS COMMITTEE

GEORGE MCK. DICK, M.E.I.C.
Chairman

In 1961 Council appointed a new committee, the Prizes and Awards Committee. This committee serves vo major functions. The first is that of reviewing and recommending to Council regarding the Institute's ver-all program of prizes and awards. The committee has completed this portion of its task. The second unction of the committee is to serve on a continuing basis as a clearing house on all matters arising in con-ection with prizes and awards and to recommend to Council regarding the composition of the individual ommittees concerned.

OMMITTEE MEMBERS:

Chairman: George McK. Dick, Sherbrooke
Members: A. C. Davidson, Toronto
Georges Demers, Quebec City

STUDENT POLICY COMMITTEE

For several years this report has mentioned a high level of student interest in the Institute, and it was maintained through 1961. As evidence of this, the number of E.I.C. Student Sections on Canadian college campuses rose from nine to twelve, and others are being considered.

Probably no other Institute event during the year exceeds in importance the annual Student Conference, in the eyes of the students themselves. An excellent one was held in Vancouver, for three days during the 1961 Annual Meeting. 31 delegates and 3 observers, representing 21 Canadian universities and colleges, convened to discuss a variety of problems, activities, and plans concerning themselves and their relationship with the E.I.C.

Normal distribution of Institute material to engineering students was again carried out during the year, and included such items as the "The E.I.C. and You" (now available for the first time in French), "Engineering Careers in Canada—1961-62", hundreds of sample copies of The Engineering Journal, and E.I.C. slide rule tie clips to all new Student Members.

The idea of Branches in university centres holding "Open House" parties for graduating class engineers, as suggested by Counci was widely discussed during 1961 and a few of them were held. More are planned for late in the 1961-62 academic year.

As for many years past, the E.I.C. continued to provide active support to the administration of the Athlone Fellowships and th International Association for the Exchange of Students for Technical Experience. These two plans provide unequalled opportuniti for engineering students, and graduates, to obtain technical training and job experience in countries other than their own. Furthe details may be found elsewhere in this report.

The student affairs report for 1961 must again pay tribute to the fine work and genuine co-operation provided by our E.I.C Faculty Advisers. Without their support much of what is being accomplished, as described above, would be difficult, if not impossibl

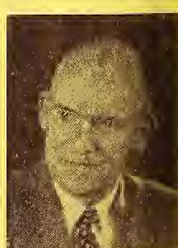
COMMITTEE MEMBERS:

Chairman: J. Hahn, Montreal
Members: Arnold Boehm, Montreal
R. E. Jamieson, Montreal
J. Lawrence, Montreal
E. Muszynski, Montreal
C. G. Southmayd, Montreal
John Walton, Montreal

J. HAHN, M.E.I.C
Chairma

TRUSTEES

JAMES H. BRACE BEQUEST COMMITTEE



During 1961 the Committee prepared for consideration of Council a "Proposed Set of Conditions and Rules of Procedure Covering the Use of Funds Earned by the Brace Bequest".

After study by the Finance Committee, these proposed conditions and rules of procedure were considered and approved by Council on September 23rd, 1961, and are being distributed to the Branches of the Institute for information and comment.

As and when further comments are received from the Branches, these, together with certain suggestions with respect to revisions which have already been submitted by Members of the Committee, will be taken under consideration by the Committee and, if considered necessary, a further report, with recommendations, will be made to Council.

BOARD OF TRUSTEES:

Chairman: D. M. Stephens, Winnipeg
Members: Albert Deschamps, Montreal
C. N. Murray, Sydney
Ernest Mason, Trail
A. T. Eric Smith, Montreal
O. M. Solandt, Montreal

D. M. STEPHENS, M.E.I.C.
Chairman

REPORTS OF REPRESENTATIVES

AMERICAN SOCIETY OF MECHANICAL ENGINEERS

The Council of the American Society of Mechanical Engineers

As a result of some effort the E.I.C. Representative to the A.S.M.E. Council is becoming recognized as a ıber of the A.S.M.E. Council to a greater degree each year.

At the December meeting there was an interesting discussion on the relationship between registration membership in A.S.M.E. There is apparently a move underway to require registration in order to ıin full membership in the A.S.M.E. This problem will go to the complete membership for a vote.

It is also interesting to see how the A.S.M.E. and other sister organizations are approaching the ›lem of Unity. They have commenced the procedure by publishing a Unified Statement of Principle. The A.S.M.E. Council is considering the approval of a recommendation put forward by E.C.P.D. to effect that all professional engineers regardless of their specialty be identified by "Ing".

H. G. CONN, M.E.I.C.
Representative

Air Pollution Controls Committee

It is somewhat difficult to separate the activities of this committee from those of the corresponding comee of the Canadian Standards Association. It seems to be highly desirable that, as far as possible, the stans adopted in the United States and Canada should be the same, and, therefore, a close liaison has been between the two bodies.

However, in view of the delays that have been experienced in the U.S.A., the Canadian Committee has led to proceed alone, at least for the time being. Nevertheless, the third draft of the proposed Canadian ', which is now being circulated, incorporates some of the proposals made by the A.S.M.E. Committee. The American draft was prepared "to assist communities in maintaining standards of atmospheric cleanlidesired by the citizenry"; it was intended to serve as a general guide, subject to local modifications.

At a meeting of the A.S.M.E. Committee, held on November 27, 1961, the legal situation of the Comee vis-a-vis the Model Clean Air Ordinance was discussed and, in view of the uncertain jurisdictional tion, it was decided to return the document to the sub-committee, for re-consideration.

As far as we are aware, no such objections arise in connection with the Canadian proposals and, as we feel that some action ld be taken now, the C.S.A. Committee is proceeding with the preparation of a Code that will be suitable for Canadian conditions, ıbmission to the parent body. However, the impasse outlined above, does indicate the complexities of the problem and it suggests, ast some reasons why progress in solving it is so slow.

E. A. ALLCUT, M.E.I.C.
Representative

ASME-EIC International Council

The Council met twice during the year—on the occasions of the Annual Meetings of E.I.C. and A.S.M.E., respectively. It cond discussion of various fields in which co-operation could be encouraged, and co-ordination effected.

During the year, two joint conferences were held—the Production Engineering Conference in Toronto, and the Hydraulics erence in Montreal—both in May, 1961. The success of these meetings confirmed Council's view as to the practicality and desirty of such jointly sponsored meetings. Careful co-ordination of plans and announcements is necessary however. A.S.M.E. tabled ailed policy and procedure to cover such situations.

Council membership for 1962 was announced as follows:

Chairman: C. G. Southmayd, A.S.M.E.
Vice-Chairman: H. N. Muller, A.S.M.E.
Secretary: O. B. Schier, A.S.M.E.
Representatives: J. David Carr, A.S.M.E.
David F. Quan, A.S.M.E.
R. S. Sproule, A.S.M.E.

Representative to E.I.C. Council:
C. G. Southmayd, A.S.M.E.
L. C. Sentance, E.I.C.
J. A. Thomas, E.I.C.
P. W. Gooch, E.I.C.
L. B. Bonneau, E.I.C.

General Secretary E.I.C.: Garnet T. Page, E.I.C.
Representative to A.S.M.E. Council: H. G. Conn, E.I.C.

L. C. SENTANCE, M.E.I.C.
Representative

CANADIAN CENTENARY COUNCIL

Your representative attended the meeting of the Canadian Centenary Council held in Ottawa on May 12 and 13, 1961. The Council met under the Provisional Chairman, Colonel Hugh M. Wallis of Montreal, and, after an address by the Prime Minister, Colonel Wallis made the report of his Provisional Executive Committee and a slate of officers was elected, headed by Brig. C. M. Drury. Mr. Robbins Elliott, Executive Director, Royal Architectural Institute of Canada, was appointed Chairman of the Program Research Committee.

A draft constitution of the Canadian Centenary Council was then presented to the meeting and adopted by the membership. The objects of the Council are as follows:

(a) To stimulate interest in appropriate observances and celebrations of the anniversary of Confederation in 1967.
(b) To establish principles and objectives and direct public attention to them.
(c) To encourage and assist in the initiation of certain projects before 1967.
(d) To act as a national clearing house and information centre and provide planning facilities and services.
(e) To encourage, undertake and assist Centenary projects.
(f) To co-operate with government at all levels and with other interested bodies.
(g) To undertake such other activities related to the Centenary as the Council may deem advisable.

Following the adoption of the constitution, Mr. Elliott divided the delegates into eight committees, each representing a general area of interest. These were:

(a) Committee on Legislation or Political Growth and Historical Plans.
(b) Committee on Physical Development.
(c) Committee on Communications.
(d) Committee on Festivals and Exhibitions and Sports.
(e) Committee on Social Health and Humanitarian Measures.
(f) Committee on Cultural Expression.
(g) Committee on Education and Scholarships.
(h) Committee on Travel and Conventions.

Each of these committees met to consider various suggestions that had been put before the Council as means of celebrating Canada's Centennial in 1967. Your representative met with the Committee on Physical Development under the chairmanship of Mr. Eric Beecroft, representing the Canadian Federation of Mayors and Municipalities. Your representative presented to the Committee the excellent brief prepared by Mr. J. H. Parker entitled "Proposal for a Canadian Museum of Science and Technology". Your representative spoke on the appropriateness of such a museum since the history of Canada has been very closely tied to developments in science and engineering and on the necessity of an immediate start to preserve exhibits and examples of Canadian engineering and science that might shortly be lost to posterity by a further delay. This brief was accepted by the Committee and was later presented to the full meeting when the Chairman gave his report.

The Committee went on to discuss other possible physical development programs and recommended that every Canadian community should have a centennial plan, making the year 1967 a deadline for the celebration of the completion of the first stage of a well considered program of community building. The Committee recommended the formation of a Physical Development Committee under the aegis of the Centenary Council in each municipality or metropolitan area. The Committee also recommended that each municipality might consider the concept of a model or centennial sector that would embrace the best features of the modern plan, a centennial program for depressed communities to devise some means of economic rehabilitation and an inventory of resources for Canada's second century of progress.

Your representative has followed up the consideration of the brief on the Museum of Science and Technology to nake sure that it receives the consideration it deserves. He has also discussed the matter with the Department of Northern Affairs and National Resources and has learned that such a museum has received consideration and that steps have been taken to preserve certain exhibits that might be of value to such a museum in the future.

BRIG. A. B. CONNELLY, M.E.I.C.
Representative

CANADIAN CONFERENCE ON EDUCATION

The Engineering Institute of Canada has been one of the member organizations of the Canadian Conference on Education since its inception. The Institute took an active part in the preparation for the first conference held in 1958 in Ottawa and has been playing an active part in the planning of the second conference.

The second Canadian Conference on Education will be held in Montreal between March 4 and 8, 1962.

The conference is being generously supported financially by the Ford Foundation and its planning has now reached an advanced stage. For example, nine Conference Studies have been prepared on the important topics listed below—copies of these may be obtained from the Conference Offices at 85 Sparks Street, Ottawa:

The major publications are: The Aims of Education, The Professional Status of Teachers, The Development of Student Potential, New Developments in Society, Financing Education, Continuing Education, Research in Education, The Citizen in Education, Education and Employment.

Five Institute delegates have been appointed and they will no doubt participate actively in the work of the various study groups. In addition several seminar sessions have been arranged, and the senior Institute delegate is Dean R. R. McLaughlin, University of Toronto.

ARTHUR PORTER, M.E.I.C.
Representative

NATIONAL JOINT COMMITTEE ON WINTERTIME CONSTRUCTION

The Committee in its meeting of February, 1960 had made useful recommendations to the Minister of Labour advocating an earlier announcement date and extended scope of the incentive program for Municipal Winter Works and these were adopted. They proved effective in quicker initiation of larger work programs.

In a September meeting the importance of detailing tidy and competent workers to undertake home projects was emphasized.

On October 12th, 1961 the eleventh general meeting of the Committee was held in Construction House, Ottawa, with fifteen members in attendance.

The Committee urged that Provincial Governments schedule their projects to provide maximum winter employment and provide incentives to Municipal Governments to adopt the same policy. Discussions took place on the outlook for 1961-62 Winter Employment and on promotional activities of member organizations.

Views were expressed that on any project that would extend over a winter, whether by day labor or contract, the Controlling Authority should direct attention, before work began or contracts let, to classes of construction that were feasible under winter conditions. These could be ear-marked for winter employment.

Consideration might be given to more direct allowances to encourage winter work by offering credits for:

(a) Increased transportation costs.

(b) Cost of heating, based on reasonable rentals for appliances plus cost of fuel or electric power.

(c) Increased cost of camp maintenance plus actual cost of winterizing.

(d) Extended overhead costs due to lost time because of severe winter conditions.

(c) Increased cost of maintaining mechanical equipment and protecting vulnerable material from frost.

These credits would be met from funds appropriated for Winter Time Construction.

Analysis of various projects would likely disclose a surprising number that were well worth-while when the overall benefits of increased winter employment were compared with the alternative of relief payments, construction delays or cancellations and the adverse psychological effect of increased unemployed workers.

J. M. WARDLE, M.E.I.C.
Representative

CANADIAN GOOD ROADS ASSOCIATION JOINT COMMITTEE ON UNIFORM TRAFFIC CONTROL DEVICES

As representative of the Engineering Institute of Canada on the Joint Committee on Uniform Traffic Control Devices, I beg to submit the following report. The disparity in highway signs, signals and markings used in Canada has long been deplored until concrete action was taken in 1956 to achieve the greatest degree of uniformity, in the shortest time possible, for both safety and ease of travel. Sponsored by the Canadian Good Roads Association, a Joint Committee undertook the study of ways and means of preparing a manual which would serve as a guide for all levels of government having jurisdiction on public roads.

On this committee were appointed representatives of all organizations interested in highway traffic, regulations, safety, transport, etc. These representations were grouped as follows:

Canadian Good Roads Association; Canadian Section, Institute of Traffic Engineers; Provincial Governments; Cities; Government of Canada; National Associations; Canadian Associations of Chiefs of Police; Canadian Automobile Association; Canadian Highway Safety Conference; The Engineering Institute of Canada.

The following subcommittees were formed: Subcommittee on Signs, Subcommittee on Signals, Subcommittee on Markings, Subcommittee on Editing—English Edition, Subcommittee on Editing—Bilingual Edition, Subcommittee on Research.

Some one hundred and fifteen (115) persons have, for a period of nearly four (4) years, contributed to the preparation of the manual and devoted much of their time attending meetings in various parts of Canada. The English Edition of the manual was published in January, 1960, and distributed since then by the Canadian Good Roads Association. Of the 5,000 copies printed some 4,300 have already been distributed, indicating the large extent of its need. The Bilingual Edition is under revision and should be available by the end of the present year. The loose-leaf form of the manual will allow changes to be made whenever traffic conditions and requirements so warrant. It will be the function of the Research Subcommittee to investigate and report to the Joint Committee on the advisability of such changes.

It has been a great privilege to represent the Engineering Institute on the Joint Committee.

J. O. MARTINEAU, M.E.I.C.
Representative

CANADIAN NATIONAL COMMISSION FOR UNESCO

During the period commencing with the appointment of this representative and ending with the date of writing this report, the Canadian National Commission for UNESCO has not held a meeting. Participation has, therefore, been limited to that of a watching brief. The Canadian National Commission distributes a good deal of literature regarding UNESCO work which has been perused with interest.

K. F. TUPPER, HON. M.E.I.C.
Representative

CANADIAN RADIO TECHNICAL PLANNING BOARD

1961 was a very active and progressive year. Sponsor representatives received some fifty communications from the C.R.T.P.B. office, transmitting information and requesting comment and/or approval of numerous sub-committee submissions and Department of Transport specifications.

The detailed work of the Board was carried out by fourteen sub-committees with considerable activity on Telephone Channel Parameters FM Broadcasting, Beam-Tilt Antennaes, Land and Mobile Transmitters and Receivers, Radio Paging, Radio co-ordination, etc.

With C.R.T.P.B. approval, your E.I.C. representative participated directly in studies being undertaken by the Department of Transport in connection with Canada's interests in Space Communications Systems and Radio Astronomy. These studies are intended to provide background for Canada's representative at the international meeting on this subject to be held in June, 1962. This meeting is sponsored by the International Radio Consultative Committee (C.C.I.R.) of the International Telecommunications Union, Study Group IV.

The Engineering Institute of Canada was represented at the Annual Meeting and at the Executive Committee meeting, held in Ottawa in December, 1961.

E. H. HAYES, M.E.I.C.
Representative

CANADIAN SCIENCE FAIRS COUNCIL

Since being appointed as the E.I.C. representative on the C.S.F.C. in August, 1961, I have attended four Council meetings, which are held on the average every two months. This report will concern itself with the history of the Science Fair movement in Canada and the work and objectives of the C.S.F.C.

More than 30 Science Fairs are scheduled throughout Canada in 1962. This represents a phenomenal growth for a movement originated in 1957 as a small fair in Winnipeg under the auspices of the Metropolitan School authorities. A science fair is an exhibit of students' scientific projects, experiments and collections, designed to motivate and encourage students to take a serious interest in the field of science as a career. A science fair may be sponsored by a school board, a service club, a parent-teacher association, an industrial group, a professional society, a newspaper, or other community organization or institution interested in encouraging the study of science among Canadian youth. The number of participants in each of these fairs ranges from 75 to 300 students.

The dual need for (a) co-ordination of the many local and regional fairs springing up across Canada and (b) provision for national competition in Canada caused the C.I.C. and the E.I.C. to initiate the formation of the Canadian Science Fairs Council in 1959, now sponsored by 13 national professional, educational, and scientific organizations. The Council's main objectives are (a) to assist the scientific professions in their active support of scientific progress and education and (b) to stimulate in the minds of young Canadians a better understanding of the contributions of science and research in present day living. The Council strives to implement these objectives by encouraging the development of science fairs in the provinces, concentrating initially in those areas where no local or regional organization is already functioning, and then working towards the establishment of a national competition for finalists from all provinces and the territories.

The first Canada-wide science fair will be held at Carleton University, Ottawa, May 11-12, 1962. It is sponsored by the C.S.F.C. and the Kiwanis Clubs of Ottawa.

The purpose of the Canada-wide science fair is to provide the final plateau of competition which to date has been available only in the United States, where the science fair's movement has been growing for more than 15 years. Two overall best awards, one for boys and one for girls, are given, which consist of expense paid trips to the International Youth Science Fortnight, London, England, July 20–August 3, 1962. Other awards include cash, bursaries, plaques and research material. Of major importance is the recognition given by the sponsors of the Council to the achievements of the finalists.

Prior to July 1961 the Council's activity was largely exploratory and preparatory. However, with the appointment of a full-time secretary and co-ordinator in July 1961, marked progress has been made in (a) the informational function, (b) the establishment of eligibility standards, (c) the establishment of a pattern of affiliation and appropriate rules and regulations for local, regional, and provincial fairs, (d) the organization and handling of the 1962 first Canada-wide science fair at Ottawa.

Although science fairs are obviously intended to reveal and recognize achievements in the sciences, the educational benefits are much broader. A student preparing a project in one of the sciences must prepare himself in related subjects such as the languages so that his exhibit may be a credit to himself in its graphic presentation and so that he may adequately explain it to the judges.

As a science fair judge, it has been a rewarding experience to see the enthusiasm, effort and interest with which highschool boys and girls present their scientific projects. I believe it imperative that we encourage scientific talents in our youth at an early age if we are to keep ahead in today's global, technological race. I sincerely hope that Council will continue to give its full support to this most needed and worthwhile movement.

H. A. MULLINS, M.E.I.C.
Representative

CANADIAN STANDARDS ASSOCIATION

Technical Committee

During the year 1961 we received a total of 57 proposed standards on which we were requested to vote approval or disapproval. These standards involved a total of 677 pages of reading material which had to be carefully gone over and digested. As a result of this we had 4 proposed standards which we questioned and this involved correspondence backwards and forwards. EIC representation on the Canadian Standards Association, Technical Council is mainly a matter of reading and studying.

E. B. JUBIEN, M.E.I.C.
Representative

Committee on Asphalt and Tar Roofing Materials

The Canadian Standards Association Committee on Asphalt and Tar Roofing Materials held four meetings during 1961, on January 13th, February 15th, June 23rd and December 7th.

Specifications were drafted for three grades of asphalt to be used for constructing built-up roof coverings. These were submitted to letter ballot and have been adopted as "A 123.7 C.S.A. Specification for Asphalt for Use in the Construction of Built-up Roof Coverings." This provides a group of asphalts that are particularly suitable for built-up roof construction under Canadian conditions.

The fourth draft of a C.S.A. specification for asphalt-saturated felted glass-fibre mat for use in construction of built-up roofs has been prepared, and is to be circulated for letter ballot.

A proposed C.S.A. specification for asphalt shingles surfaced with mineral granules has reached the stage of the third draft.

The Canadian Standards Association has authorized the Committee to write application specifications for tar and asphalt roofing materials. Drafts of application specifications are being reviewed for asphalt strip shingle application on roof slopes of 4" in 12" or greater, and on roof slopes of from 2" to 4" in 12".

The Committee on Asphalt and Tar Roofing Materials is considering the preparation of a "Code of Practice", similar to that issued by the British Standards Institution to assist architects and others to design roof coverings tbat are adequate for specific structures.

The Committee has asked the Canadian Standards Association for a statement of policy concerning the interpretation to be given to the maximum and minimum limits stipulated in C.S.A. specifications. The specific question on which a ruling is requested is, "do the maximum and minimum limits apply as they are listed, or are the limits of acceptance considered to lie within the full range between the minimum specified limit minus reproducibility to the maximum specified limit plus reproducibility?"

NORMAN W. MCLEOD, M.E.I.C.
Representative

COLUMN RESEARCH COUNCIL

The Column Research Council of the Engineering Foundation concerns itself with problems relating to tbe strength, design, and behaviour of columns and other compression elements in metal structures. The Engineering Institute of Canada is one of a large number of technical and professional organizations with delegate members of the Council.

The work of the Council, which primarily involves the co-ordination and review of various researches, is carried on through technical committees and working groups, with an annual technical meeting for interchange of ideas and committee meetings. In 1961, the annual general and technical meetings were held at the George Washington University, in Washington, D.C. in April. As well, in 1961, tbe Executive Committee and Chairmen of Research Groups met in New York in October.

In 1960, the Column Research Council published a "Guide to Design Criteria for Metal Compression Members" which has been well received. A second printing of the "Guide" was ordered in 1961, and many copies are evidently in use in Canada in design work. The influence of the "Guide" can be seen very clearly in the provisions for the design of structural steel in the National Building Code (1960), and the new edition of CSA-S16, Steel Structures.

It is anticipated that the next major contribution from Column Research Council will be an enlarged second edition of the "Guide" covering additional important structural types.

D. T. WRIGHT, M.E.I.C.
Representative

EMERGENCY MEASURES ORGANIZATION

Whilst there has been considerable activity within the Emergency Measures Organization during the last year, there has not been, however, any request for assistance from the Institute directed to your representative.

A meeting is scheduled for early March to explore areas where assistance might be useful and a course for engineers in Survival is scheduled, at the Canadian Civil Defence College at Arnprior during the period of April 30th to May 4th. The Institute has been invited to send fifteen delegates to this course and the Branch Chairmen across Canada have been requested to submit a list of interested engineers. The College pays all travel and living expenses for the course.

Your representative was a member of a committee established to develop a suitable specification for a portable 10KW emergency power plant for the Emergency Measures Organization mobile emergency hospitals. This specification has now been issued by the Dominion Government Specification Board under their listing 76-GP-1.

R. E. HAYES, M.E.I.C.
Representative

SECOND INTERNATIONAL HEAT TRANSFER CONFERENCE

The 2nd International Heat Transfer Conference took place in Boulder, Colorado during the last week of August, 1961. Held in a picturesque setting on the campus of Colorado University in the foothills of the Rocky Mountains, and preceded by over two years of intensive planning and preparation in which the representative of the Engineering Institute participated actively, the conference proved to be a great success.

It was jointly sponsored by two American and two British societies (A.S.M.E., A.I.Ch.E., I. Mech. E. and I. Ch. E.) with the participation of nine others (including the E.I.C.), and was attended by nearly 800 engineers from all over the world, including about 20 from Canada. Europe was well represented with about 20 delegates from the United Kingdom and others from Belgium, France, Hungary, Italy, Sweden and Switzerland. Even such faraway countries as Japan contributed papers and sent delegates.

The conference lasted a full week with 121 papers being presented. These were grouped according to topics and summarized by rapporteurs. Summaries, which without exception were excellently prepared, stimulated animated discussions which at times proved so lively that they continued well into the evening hours at individually organized impromptu sessions.

The daily discussions were chaired by two co-chairmen, usually representing the United States and Great Britain. Two Canadian delegates (Dr. W. Gauvin, M.E.I.C., representing the Chemical Institute of Canada and Professor J. W. Stachiewicz, M.E.I.C., representing the E.I.C.) served as chairmen at two of the sessions.

The conference was highlighted by four special lectures given by the foremost authorities in the field of heat transfer. The Dr. Eckert spoke on "Research on Forced Convection," Dr. Saunders (U.K.) on "Progress in Engineering Heat Transfer Science," Dr. Hottel on "Radiation" and Dr. Schmidt (Germany) on "Free Convection."

Following the precedent set in 1951 when the 1st International Heat Transfer Conference was held in the United Kingdom and

an additional discussion was later arranged in the United States, the Boulder Conference was followed by a discussion in London in January, 1962.

Complete proceedings of both meetings will be published by the A.S.M.E. and should be available before the end of 1962.

JULES W. STACHIEWICZ, M.E.I.C.
Representative

NATIONAL CONFERENCE ON EDUCATION

The conference was opened with much circumstance by the Governor General and the opening addresses were intended to convey the magnitude of the tasks ahead and results already achieved. This delegate gained the impression the conference was a place for exchange of ideas between individual professional educators as well as those engaged in special activities relating to the training or education of adults, for example, some CBC representatives, certain organizers of special agricultural training programmes, etc., etc. It did not seem to me to have too much in common with a professional society such as E.I.C., which deals with discussions and publications of trained specialists.

This is only the second such conference, and E.I.C. may well wish to be represented again to observe the development of this particular group. It did gather people from all over the country and it was well organized and well run. Most of the discussion took place in small groups and a digest of these group opinions was reported back to the whole assembly.

J. T. HENDERSON, M.E.I.C.
Representative

NATIONAL RESEARCH COUNCIL ADVISORY COMMITTEE ON BUILDING RESEARCH

During 1961 one special meeting of the Committee was held on September 21st, 1961. The chief purpose of this meeting was to enable the Committee members to meet the Directors of Building Research of the British Empire and the United States who were holding their regular five-yearly meeting in Ottawa at that time.

E. R. SMALLHORN, M.E.I.C.
Representative

CANADIAN NATIONAL COMMITTEE SIXTH WORLD PETROLEUM CONGRESS

The Committee, consisting of the following, has held three meetings—April 26th, 1961, May 18th, 1961 and August 29th, 1961—and contemplates a fourth meeting on March 22nd, 1962.

Chairman:
Dr. G. W. Gurd
Imperial Oil Limited, Sarnia
Secretary:
Mr. F. P. Irwin
111 St. Clair Avenue West
Toronto, Ontario
Dr. J. F. Caley
Geological Survey of Canada
Department of Mines & Technical Surveys
Ottawa, Ontario

Mr. C. E. Carson
111 St. Clair Avenue West
Toronto, Ontario
Dr. R. J. W. Douglas
Geological Survey of Canada
Department of Mines & Technical Surveys
Ottawa, Ontario
Dr. D. L. Flock
University of Alberta
Edmonton, Alberta

Dr. G. W. Govier
University of Alberta
Edmonton, Alberta
Mr. A. W. Hutchinson
Shell Oil Company of Canada Limited
Box 400, Terminal A
Toronto 1, Ontario
Mr. N. W. Martison
Colorado Oil & Gas Limited
309—7th Avenue S.W.
Calgary, Alberta

In the early meetings of the Committee it was agreed that the Committee should solicit eight Canadian papers (this being the number approved by the Central Organizing Committee of the Congress) distributed as follows:

Section 1: Geophysics and Geology—3; Section 2: Drilling and Production—2; Section 4: Base Stocks from Petroleum and Natural Gas for the Chemical Industry—1; Section 5: Composition, Analysis and Testing—1; Section 7: Engineering, including Materials and Transportation—1.

At my request to you suitable publicity concerning the Congress and a request for papers was announced through the Engineering Journal.

At a meeting held in Winnipeg August 29th, 1961 the Committee reviewed the titles and abstracts which it had received. From the sixteen papers proposed the Committee selected seven technical papers following within the topics, Sections I—VIII, inclusive, and one paper for presentation at a proposed panel discussion. The papers are as follows:

Section I—GEOLOGY AND GEOPHYSICS—"Geology and Petroleum Potentialities of Northern Canada," *R. J. W. Douglas*, *D. K. Norris*, *R. Thorsteinsson* and *E. T. Tozer* of Geological Survey of Canada. "Seismic Exploration for Reefs," (to be developed) of Imperial Oil Limited, Western Producing.

Section II—DRILLING AND PRODUCTION—"Arctic Drilling," *Peter Bawden Drilling Limited.*

Section IV—BASE STOCKS FROM PETROLEUM AND NATURAL GAS FOR THE CHEMICAL INDUSTRY. "Data to the Theory of Aromatic Alkylation," *George A. Olah* of Dow Chemical of Canada or Submission by Union Carbide.

Section VI—UTILIZATION OF PETROLEUM AND OF NATURAL GAS PRODUCTS. "Four Depressants for Middle Distillates," *C. H. Caesar* and *J. L. Tiedje* of Imperial Oil Limited—Research Department.

Section VII—ENGINEERING INCLUDING MATERIALS AND TRANSPORTATION. "Rheology of Crude Oils and Applications to Pipe Line Design," *G. W. Govier*, University of Alberta.

Section VIII—STATISTICS AND EDUCATION—"The Evaluation of Wildcat Acreage—An Operations Research Approach," *D. G. Quirin* and *A. D. Hunt* of Department of Northern Affairs and National Resources.

In addition the Committee proposed the names of four persons who might give review papers and the names of one person who might give a general lecture at the Congress.

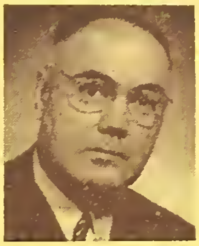
The recommendations of the Canadian National Committee were considered at a meeting of the Executive Committee of the Permanent Council for the World Petroleum Congress January 16th and 17th, 1962 at The Hague. At this meeting the seven technical papers proposed by the Canadian National Committee were given final acceptance, together with the proposed contribution to a panel discussion on education for the petroleum industry. The suggestion from the Canadian National Committee that Lewis G. Weeks be invited to present a review on petroleum exploration was also accepted.

The Canadian National Committee has also given consideration to its responsibility in connection with the raising of funds to help support the Congress. This and other matters will be dealt with at the forthcoming meeting of the Committee March 22nd.

In summary, I believe that I can report that the Canadian National Committee has completed its work with respect to the obtaining and selecting of suitable papers for presentation at the Congress and that it now has before it the task of soliciting financial support for the Congress and other details such as the possibility of arranging charter aircraft transportation and the like.

G. W. GOVIER, M.E.I.C.
Representative

UPADI



As your representative, it is my privilege to report to you on the activities of Union Panamericana De ociaciones De Ingenieros (UPADI) for the past year.

Copies of minutes and reports indicate that the Board of Directors has been very active. UPADI has complished much in developing close relations between the Engineering Societies of the various member untries. There has also developed an active and keen desire for more Engineering education in all Latin-nerica.

Mr. Carlos Vegh Garzon, our representative on the Board of Directors, continues to serve us faithfully, ich he has done since UPADI was organized in Cuba in 1950. He is a very regular attendant at all meetings. s ability and knowledge of South American affairs give us a strong voice in the organization.

The need for development in South American countries is providing opportunities for Canadian Engineers, pecially those trained in specialized fields such as mining, oil refinery and industrial processes. Canadians e now entering these fields as Consultants.

UPADI Conventions are held every two years. Argentina was the host country in 1960 with meetings held in Buenos Aires, ierto Rico will be the host country for the 1962 Convention to be held August 19th, to 26th. Each representative country may have n accredited delegates and each delegate may invite Engineers as guests, all of whom may participate in the meetings.

This is an opportunity for Canadian Engineers to meet Engineers from every country of South and Central America and may xpress the hope that there will be a large Canadian delegation.

Our contribution to UPADI has been substantial. Canada and her Engineers are much better known to the Engineers and other ople of South America because of our participation. I hope that we will continue to be active and give vigorous support to this ganization and our Engineers take advantage of the opportunities in the development of South America.

The financial affairs of UPADI continue to be managed in very frugal and careful manner.

I would like to recommend to you, Mr. President, that our appreciation be conveyed to Dr. Giannattasio, Mr. Vegh Garzon, r. Giorgi and other members of the Board of Directors for the dedicated and faithful service rendered on our behalf.

JAMES A. VANCE, HON. M.E.I.C.
Representative

ENGINEERS' COUNCIL FOR PROFESSIONAL DEVELOPMENT

The activities and progress of the Engineers' Council for Professional Development for 1961, were most satisfactory and the llowing highlights should be of interest to all members of E.I.C.

During the year, two new participating societies were added to the Council membership. The two new societies, namely "The stitute of Aerospace Sciences" and "The Institute of Radio Engineers" are vigorous organizations and should contribute materially the work of the Council.

The proposed amalgamation of the Engineers' Joint Council and E.C.P.D. was defeated by the vote of the constituent societies the proposal submitted by the joint E.J.C.—E.C.P.D. Planning Committee.

The Junior Engineering Society (J.E.T.S.) which sponsors chapters in High Schools for guidance toward engineering studies, s a membership of 24,000 in 825 clubs. During the year, the Engineering Foundation granted $25,000.00 to J.E.T.S. to implement e transfer of their headquarters to the new United Engineering Centre in New York. It was agreed that this increasingly important tivity should ultimately be under the guidance of E.C.P.D.

E.C.P.D. decided during the year to discontinue the accreditation of correspondence courses due to the almost impossible task evaluating the products of such courses.

The Recognition Committee under the Chairmanship of Guy Savard presented the following definition which was approved Council as E.C.P.D.'s official wording. "Engineering is the Profession in which a knowledge of the mathematical and natural iences gained by study, experience and practice is applied with judgment to utilize, economically, the materials and forces of ture." Council also approved the proposal by this committee that the abbreviated title "Ing." (based on the historic spelling of ngenier") should be used as a common designation for all engineers. This proposal is being referred to the constituent societies r ratification before official adoption.

The Education and Accreditation Committee reported the evaluation of 288 curricula in 72 institutions during the year and e subcommittee's report on the accreditation of technical institutes showed that 38 curricula in 13 institutions had been evaluated.

Studies are being continued on the increasing value of accreditation of post graduate studies due to the continuous development new processes and procedures and the consequent inherent trend of absolescence in all the work of the engineer.

As a member of the E.C.P.D. Council for the past four years, one cannot help but admire and commend the volume of work rformed by the members of the E & A Committee. The result of this work is a continuous advancement in the quality of minimal andards in engineering education. Your councillor cannot help but feel that a national accreditation procedure should be instituted Canada using as a pattern, the techniques and procedures which have been developed by the E & A Committees of E.C.P.D. over e past thirty years. The members of this committee are not only carefully selected by the committee itself for their educational ility and personal characteristics, but are trained by experience as they progress in the procedures of accreditation.

Today's exploding technology, together with the vast increase forecast in Canadian University population during the next ten ars indicates additional curricula, University facilities and professional staff. In Ontario alone, seven new engineering faculties ve been established in the past five years.

The present accreditation programs in Canada are basically performed by the Provincial Professional Associations and this uld lead to eleven different standards in Canada. Accreditation should only be performed on a national basis and it would be most grettable if our high standard of Canadian education were to suffer by reason of the problems associated with abnormal growth. is doubtful whether any one organization could supply the personnel for all evaluation requirements, but it would seem most sirable that the Engineering Institute should start the formation of such an organization. The Institute should have the background owledge for such an assignment as some of their members have had the opportunity to participate as observers on the E & A ommittees.

The preceding suggestion is necessarily expressed as briefly as possible for this report, but could be expanded in depth by the pointment of qualified members of the Institute. During the year there has been active participation on all committees by E.I.C. rsonnel.

The Guidance Committee concentrated their efforts on a program of "Engineering as a Career" at the secondary school level, ntacting 100,000 students by 1,500 meetings. These were supplemented by the circulation of some 130,000 pamphlets on the same bject. Both the Student Development Committee and the Committee on the development of the Young Engineers were vigorous the performance of their responsibilities and their work through local sections is providing "revitalized" programs and literature r this group of engineers in their formative years.

The Ethics Committee is actively reviewing the Canons of Ethics of E.C.P.D. and is trying to establish E.C.P.D. as a clearing ouse for such codes or rules established by the Constituent Societies.

All executive and council meetings have been attended by your appointees.

G. R. HENDERSON, M.E.I.C.
Representative

TABULATION OF BRANCH ACTIVITY ANNUAL REPORTS

Branch	No. of Meetings	Technical Meetings: Field	Attendance	Social and Other Activities: Nature	Attendance	Joint Meetings	No. of Executive Meetings	Other Activities
Amherst	4			President's Visit Annual Meeting "Function of EIC" "Function of Professional Association of Engineers"	50 11 25 26		5	
Baie Comeau	10	Metallurgical (1) Construction Underwater (1) Instrumentation (1) Explosives (1) Space Technology (1) Field Trips Grain Elevator (1) Mining (1) Hydroelectric (1)	38 45 11 37 51 31 40 45	Annual Dance Presidential Visit	98 91	Represented at Quebec Regional Technical Conf.	7	High school student counselling and miscellaneous local activities such as bursaries and scholarships were carried out.
Belleville	8	General (1) Civil (1) Electrical (1) Civil Defence (1)	30 15 20 12	Dinner Meeting Plant Tour President's Night Ladies' Night	25 35 50 35		10	An annual prize of $75 was awarded to the Grade XIII student who plans to enter engineering with highest aggregate marks.
Border Cities	9	General (3) Mechanical (1) Civil (1)	30 32 62	Smoker Dances (2)	47 161	Annual joint meeting with APEO. APEO President guest speaker	10	The President of the local Student Section attends Branch Exec. meetings. The Branch sponsored a Student Papers meeting at which $85 in prizes was distributed. The Ladies Auxiliary is active.
Brampton	2						3	
Brandon								
Brockville	9	General Industrial (5)	30	Visit of Gen. Sec. Golf Tournament Annual Meeting	47 3 33	Joint EIC—APEO	38	The 1961 PD course comprised a series of 8 lectures on Industrial and Business Administration. Enrolment included 10 EIC members. Preparation was made for a Science Fair for 1962.
Calgary								

Branch	No. of Meetings	Technical Meetings		Social and Other Activities		Joint Meetings	No. of Executive Meetings	Other Activities
		Field	Attendance	Nature	Attendance			
...pe Breton	9	Metallurgy (1) Civil (1) Mining (1)	40 35 30	Reception for N.S. Tech. Dance Annual Lobster Party Presidential Visit Talk on Civil Def. Annual Business Meeting	50 100 85 100 35 25	Joint Meetings with CIC Speaker Dr. J. T. Elliott, M.I.T.	13	In co-operation with Dosco, Sydney, a visit was sponsored through Sydney Steel Plant for Senior Mech. students from N.S. Tech. The Branch is building a scholarship fund to institute a Bursary. There were 4 regular and 3 ex. mtgs. of the Eng.'s wives.
...ntral B.C. Branch	6	Oil Industry (1) Natural Resources (1)	28 20	Annual Meeting Kootenay Br. Visit President's Visit Social Evening	17 10 50 36	Joint mtgs. held with A.P.E., B.C.		
...alk River	8	Nuclear (1) Aerospace Research (3)	20 35	Address by Gen. Sec. Field Trip to TV Station	20 25	One Aerospace Research with CIC Two with APEO re formation of Algonquin Chapter	7	Branch sponsored beginning of APEO Algonquin Chapter. Local high school students interested in Engineering were invited to Atomic Energy of Canada to show engineers at work. Presented a handbook to the best local high school student entering a university Engineering Course.
...ner Brook	6	Civil (3) Electrical (1) Instrumentation (1)	20 15 14	Dinner Meeting and Election of Officers	25		3	EIC Wives Club has been active.
...nwall	9	Civil (1) Mechanical (1) Industrial (1)	30 15 30	Annual General Meeting Plant Tour Ladies' Night	22 11 36		10	The $200 Magwood Bursary was awarded this year, divided among three students. The branch assisted at a local high school symposium "Sojourn in Science."
...tern Townships	9	Environment Engineering (1)	35	President's Visit Annual Meeting Golf Tournament Quebec Minister of Public Works Future of Mfg. Industries in Canada	85 100 40 50 50	Joint Meetings with C.I.M.M. and C.P.E.Q.	5	A Panel was held on Confederation. Science Week was observed Nov. 27, 1961; there were Joint E.I.C.-Student body activities with a visit of the Science Faculty $25 was presented to Claude Desrosiers, 3rd yr. engineering student
...monton	10	General (7) Civil (1)	95 101	Dance Annual Meeting and President's Visit Picnic Meeting on Confederation	67 300 52		10	The Engineers Wives Club had a very active year
...evan Section	9	Petroleum (5) Engineering Profession (2) Civil Defence (1)	24 25 18	Council Meeting Dinner Dance (2) Barbecue and Golf	6 10 35	Representation at Saskatchewan Branch Annual Meeting	6	A panel discussion was presented at Broadview High School Plans were formulated to donate a $100 annual scholarship to high school students who plan to enter engineering

Branch	No. of Meetings	Technical Meetings		Social and Other Activities		Joint Meetings	No. of Executive Meetings	Other Activities
		Field	Attendance	Nature	Attendance			
Fredericton	8	Photo-grammetry (1) Student Papers (1)	35 40	Dinner Meetings (4) Christmas Dance Entertaining Graduate Engineers	45 90 45	A.P.E.N.B. invited to Branch Dinner Meetings	8	Prizes were awarded for the Student Papers Competition
Halifax	9	Civil (2) Electrical (2)	50 70	Lobster Parties (2) Confederation Social Evening for Graduating Class N.S.T.C. Annual Meeting	180 70 200 35	One meeting with with N.S. Association of Architects and Military Engineers Assoc.	7	A Student Branch was established at N.S.T.C. The Professional Eng. Wives Association was very active
Hamilton	23	Industrial Relations (4) Regional and Economic Development (6) Civil (3) General (3)	50 50 40 40	Annual Ball Christmas Party Fall Stag Annual Meeting	250 68 39 62	Joint Meeting with A.S.Q.C. and C.I.M.A. Meeting with A.I.E.E. Meeting with McMaster Student Engineering Society	8	The Professional Development program is attracting interest from approximately 80. Student counselling activities were carried on at McMaster University and High Schools and a $1000 Loan Fund was created for McMaster. Assistance was given the Niagara Branch to promote 3rd Regional Conference
Huronia	2			Dinner and Dance Annual Meeting	27 6		2	
Kingston	8	Traffic Engineering (1) Industrial (1) Metal Cutting (1) Aeronautical (1) Town Planning (1) Students Papers (1)	27 39 32 25 61 31	Annual Meeting Confederation Meeting	109 50		9	Assistance was given to organize a science fair for local high schools held in March, three awards totalling $75 were presented for papers by undergraduate engineering students at Queen's and R.M.C.
Kitchener								
Kootenay	6	Chemical (2) Research (1)	32 36	Presidential Visit Central B.C. Branch Exchange Visit Annual Meeting	28 27 30	C.I.C. Members were invited to one meeting	8	A visit to a Kootenay Pulp and Paper industry was attended by 25
Lakehead	6	General (3)	28	Annual Dance Annual Meeting	50 40	Two meetings with A.P.E.O.	10	
Lethbridge	9	Civil (2) Electrical (1) Industrial Development (1) Civil Defence (1)	42 27 27 32	Presidents' Visit Opening Stag Dinner Meeting and Field Trip Engineers Ball	54 28 37 83		12	"Engineering Careers in Canada" were sent to High Schools. The Ladies Auxiliary was very active
London	7	Civil (1)	35	Annual Dance President's Dinner Feather Party	90 50 35		9	A students' night was held with a panel of local engineers. Professional Development included a program on Corporation and Civil Law by the University Faculty. The Wives Group was very active.

Branch	No. of Meetings	Technical Meetings		Social and Other Activities		Joint Meetings	No. of Executive Meetings	Other Activities
		Field	Attendance	Nature	Attendance			
ower St. Lawrence	7	Navigation (1) Electrical Power (1) Telephone (1) Petroleum (1) Civil (1)	15 12 7 20 10	Annual Party Presidential Visit	35 27	All meetings organized with C.P.E.Q.	7	
oncton	7	Hydraulic (1) Structural (1) Railway (1) Electrical (1)	58 42 29 35	Meeting with General Secretary Annual Meeting Panel on Confederation	76 30 36		6	
ontreal	38	Management (4) Chemical (7) Civil (9) Electrical (10) Mechanical (8) Associate Section (3)	64 64 64 64 64 64	Annual Dinner Dance Oyster Party	478 138	Electrical Section meetings held jointly with A.I.E.E. Chemical Section meetings held jointly with C.I.C.	10	Professional Development Seminar given by Associate Section. The Branch presented speakers representing the Engineering Profession at "Career Nights" organized at high schools and Home and School P.T.A. groups. Sponsored Montreal Science Fair. A spring golf social, student's night and associate paper night were sponsored by the Associate Section
oose Jaw	7	Hydro Electric (1) Films (Technical) (1)	23 20	Tour of Steel Mill President's Visit Films (Non-technical) Visit to Stock Exchange Archeology in Sask.	16 60 20 25 22	Represented on: Moose Jaw Productivity Council Moose Jaw Winter Employment Fact Finding Committee	5	Kiwanis Club participation local High Schools "Career Night". Provided information on courses for Engineering Technicians to Sask. Technical Institute
ewfoundland	6	Mining (1) Civil (1)	54 55	Student Public Speaking Contest Business Meeting Dinner Meeting	20 30 43	Joint Meeting with Military Engineers Assoc.	9	$50 prize awarded in Engineering Students Public Speaking Contest. Engineers Wives presented a $100 Scholarship to 2nd Year Engineering Student at Memorial Univ. and $80 worth of technical handbooks to the Eng. Dept.
iagara Peninsula	8	Nuclear (1) General Film (1) Plant Tours: Steel (1) Industrial (1) Structural (1) Tour—Canal (1)	63 70 75 42 20 42	President's Visit Engineers Dance Ladies' Night Junior Engineers	35 240 120	A.P.E.O. were invited to meetings, Regional Conference	12	A Professional Development Course was held. Speakers were provided for "Career Days" in local High Schools
ipissing and Upper Ontario	8	General (1) Electrical (1) Mechanical (1) Civil (1) Instrumentation (1)	27 17 34 30 23	Annual Meeting Students' Night Regional Conference	16 79 145		5	Each member sponsored a student to a dinner meeting on student's night. Wives Association held four meetings
orth Eastern Ont. Section				Mr. L. C. Sentance A.P.E.O. Annual Meeting	30 8		4	
orth Nova Scotia		No meetings held						

Branch	No. of Meetings	Technical Meetings		Social and Other Activities		Joint Meetings	No. of Executive Meetings	Other Activities
		Field	Attendance	Nature	Attendance			
North Shore Lower St. Lawrence	6	Hydro-Electric (1) Communications (1) Railroad Construction (1) Chemical (1) Construction: Harbour (1) Underwater (1)	35 18 36 12 19 22	Annual Branch Meeting and Presidential Visit	109		5	
Northern New Brunswick	4			Dinner and Speaker (3) Annual Meeting	33 36		3	
Oakville	6	General (5)	10	President's Visit	40		8	
Ottawa	13	Field Trips (2) General (7)	50 60	Golf Tournament Engineers-Architects Dance Annual Meeting	60 100 50	Joint Meeting with A.I.E.E. (1) M.E.A.C. (1) and I.TrafficE. (1)	10	A very active P.D. with average atten ance at meetings 35-40. Two $50 pri were presented to e gineering students Carleton and Otta Universities
Peterborough	5	Civil (1) Nuclear (1)	49 65	Dances (2) Non-technical— Social (2) Dinner (2)	70 35 40	Confederation Meeting with local A.P.E.O. Chapter	15	1961 Executive o ganized Nucle Power Exhibiti with aid of C.A.P. Dept., C.G.E. a A.E.C.L. Awards $15 each were pr sented to top studen in math and physi at four local Hi Schools
Port Credit	6	Construction (1) Plant Tours— Oil Industry (1) Brewery (1)		Preliminary Branch Formation Meeting Inauguration and Presentation of Charter Discussions on Confederation, Constitution and Branch Activities				
Port Hope	5	Tour— TV Station	40	Smoker General (3)	23 23		4	
Prince Albert	27	Electrical (2) Physics (3) Civil (2)	9 10 10	Dinner Socials (2) Hosts to Provincial Council at Prince Albert Park	14 16			An engineering pan was held at the loca High School to advis on engineering caree
Prince Edward Island	3	Illumination (1)	20	Dinner	30	Joint Meeting with A.P.E.P.E.I.	8	
Quebec, Quebec	8	Civil (2) Electrical (1) Metallurgy (1)	44 40 18	President's Annual Visit Branch Annual Meeting Lecture on Visit to Russia by Mr. Lawton and Mr. Grant Annual Golf Tournament	50 25 40 90		8	Advanced Structur Eng. for Laval stu dents sponsored. On informal speech b senior Member fo students only. Stu dent counsellin through Faculty Ad visor. Regional Tech nical Conference hel in Nov. Member active in Community

Branch	No. of Meetings	Technical Meetings		Social and Other Activities		Joint Meetings	No. of Executive Meetings	Other Activities
		Field	Attendance	Nature	Attendance			
na Section	52	Professional Development Course Regular Monday Noon Luncheon	50 35	Golf Tournament Informal Dances (2)				There is a Ladies' Group whose activities include bridge, ceramics, handicrafts, millinery and ballroom dancing
mond Hill		General	25				4	
enay	10	Chemical (1) Electrical (1) Mechanical (1) Industrial Relations (1)	25 23 27 75	Annual Meeting Presidential Visit Confederation Panel Annual Dance	22 26 42 275	Meeting on Chemical Engineering held jointly with C.I.C. Executive Meetings held jointly with C.P.E.Q.	9	Varied engineering courses were offered to members. The Branch executive co-operated with C.P.E.Q. and C.I.C. in arranging meetings at local high schools with senior students
t John	12	Civil (1) Lighting (1)	44 12	Mixed Dinners (4) Plant Tours (2)	42 60	One joint Dinner with A.P.E.N.B.	14	Professional Development program was started this year with three lectures held out of a series of 12 at which average attendance was 39
t Maurice Valley	10	Ceramics (1) Electrical-Mechanical (1) Municipal Services (1) Electrical (1) Plant Visit—Electrical (1)	35 20 80 15 10	Annual Meeting Presidential Visit Confederation Panel Banquet and Dance Golf Tournament	35 60 20 60 50	E.I.C.-A.I.E.E. Joint Technical Meeting A.I.E.E. and C.P.E.Q. invited to social functions	4	
nia	10	Computers (1) General (3) Underwater (1) Plant Tour—Chemical (1)	70 87 104 74	Engineering Experience Annual Dinner Dance and Presidential Visit Men's Stag Annual Meeting	210 96 41 83	One meeting held with C.I.C. and one with Michigan Society of P.Eng. Most activities carried out jointly with A.P.E.O.	12	A course of 8 Professional Development lectures on computing was held. Engineering guidance given to students at 3 High Schools. A student prize of $40 was donated
katchewan		See Sections— Prince Albert Saskatoon Yorkton Regina Estevan					9	
katoon ection	9	Average Attendance	80					This Section participated actively with Engineering students at University of Saskatchewan
lt te. Marie	8	Bridge (1) Electrical (1) Harbour (1)	36 19 19	Annual Business Meeting General Secretary's Visit Survival from Nuclear Attacks	18 32 24	Three joint meetings held with local A.P.E.O. Two were chaired by A.P.E.O.	4	Engineering Wives Association held one meeting
lbury	9	Mechanical (1) Civil (1) Industrial (1) Electrical (1) Mining (1) Field Trip (1)	43 40 41 38 136 58	Annual Ladies' Night and President's Visit Ladies' and Guests' Night Confederation	113 73 30		10	An "Engineering Students' Career Night" was attended by approximately 50 senior students All branches of engineering were represented by Branch members

Branch	No. of Meet-ings	Technical Meetings		Social and Other Activities		Joint Meetings	No. of Execu-tive Meet-ings	Other Activities
		Field	Atten-dance	Nature	Atten-dance			
Swift Current	26	Dinner Meetings	20					Attendance 20 c of 35
Toronto	29	Civil (6) Power (5) Electrical (8) Management (3) General (2)		Ladies' Night (Dance) President's Visit Field Trips (2) Confederation Annual Meeting	250 100 100 60	One joint meeting was held with A.I.E.E. and one with A.S.M.E.	9	Three active Prof sional Developme Groups. Some st dent counselling ac vities are carried o
Vancouver	26	Civil-Structural (4) Management (5) Natural Resources (4) Mechanical (7) General (1) Field Trips (3)	35 25 15 25 25 75	Salmon Fishing Derby Annual Meeting	10 49	Four joint meetings with A.P.E.B.C.	12	The Professional D velopment Activit included a series lectures on "Econor of Canada". A St dents' Night Dinn was held. The E.I. Vancouver Bran Prize of $100 a the Walter Mober Memorial Prize of $ were awarded U.B.C. Students
Vancouver Island	8	Civil (4) Management (1)	70 30	President's Visit General Secretary's Visit Confederation Lunch	60 54 32	Joint meetings held every other month with A.P.E.B.C.	10	$100 scholarship giv the most active e gineering student Victoria College. T Engineers' Wiv have been active
Whitby	3	General (1) Industrial Safety (1)	12 9	Presentation of Charter	76			
Winnipeg	32	Civil (7) Electrical (6) Soils (2)	40 44 112	Annual Dance Electrical Section Dance Spring Wind-up	350 250 166	One joint meeting with A.P.E.M. to acquaint students with functions of each organization	10	A Professional D velopment Sub-Co mittee was set up aid Student Sectio Three summer thes prizes with meda and three stude papers prizes we presented
Yorkton Section	26					Of special interest was the annual meeting of the Saskatchewan Division of the American Public Works Association. 5 papers on "Soil Cement"		
Yukon	6	Geology (1) Transportation (1) Engineering Law (1) Civil (1)	18 20 10 17	Dinner Special Non-Affiliate Meeting	20 10		2	

MEMBERSHIP AND FINANCIAL STATEMENTS OF THE BRANCHES AT DECEMBER 31, 1961

BRANCHES	Amherst	Baie Comeau	Belleville	Border Cities	Brampton	Brockville	Calgary	Cape Breton	Central British Columbia	Chalk River	Corner Brook	Cornwall	Eastern Townships	Edmonton
MEMBERSHIP														
embers	..	..	..	..	..	..	1	..	..	1	..	..	..	1
mbers	4	..	3	8	..	2	15	5	9	..	..	2	8	6
s	24	31	50	132	24	53	556	63	39	37	31	55	97	575
e Members	8	14	16	20	6	20	102	21	10	26	10	12	62	225
s	9	5	9	76	6	6	91	12	30	8	19	13	152	172
s	..	4	2	..	..	..	2	2	1	..	..	..	..	1
	45	54	80	236	36	81	767	103	89	72	60	82	319	980
NCIAL STATEMENT														
from E.I.C. Hq. (1)	81.80	171.90	173.55	550.43	100.00	290.06	328.08	104.45	114.97	126.18	126.30	354.55	522.54	288.06
nces from Prof. Assns.	35.70	..	..	..	..	..	1,615.03	285.60	..	..	..	..	..	1,925.41
Affiliate Dues	..	351.00	4.00	20.00	..	195.00	468.00	360.00	129.15	..	..	..	284.00	90.00
	..	..	..	31.50	..	..	84.89	..	..	..	..	..	6.50	101.75
neous	231.84	615.00	279.26	1,217.97	..	40.00	..	1,474.00	..	139.35	68.00	365.90	439.70	339.50
Receipts	349.34	1,137.90	456.81	1,819.90	100.00	525.06	2,496.00	2,224.05	244.12	265.53	194.30	720.45	1.252.74	2.744.72
ments														
and Communications (2)	7.27	24.92	51.28	191.78	..	88.90	758.26	21.98	103.28	40.91	1.32	41.83	118.08	417.76
Expenses (3)	287.19	1,189.85	295.30	1,513.19	..	299.90	691.58	2,036.90	99.72	225.86	110.05	748.92	987.66	1,013.70
iums and Steno Services	..	..	..	43.25	..	..	480.44	..	..	4.45	..	..	..	416.48
ng Expense (4)	..	..	14.25	..	..	..	..	..	..	..	..	..	..	273.90
tions (5)	..	4.00	..	13.00	..	36.00	..	148.00	56.00	..	..	..	60.00	5.00
Expense	..	18.79	90.00	64.10	..	31.00	57.99	151.52	8.00	10.60	4.00	..	35.90	25.05
Disbursements	294.46	1,237.56	450.83	1,825.32	..	455.80	1,988.27	2,358.40	267.00	281.82	115.37	790.75	1.201.64	2.151.89
us	54.88	..	5.98	..	100.00	69.26	507.73	..	..	..	78.93	..	51.10	592.83
it	..	99.66	..	5.42	..	..	..	134.35	22.88	16.29	.	70.30	.	..
at Dec. 31st, 1960	150.46	385.00	134.53	1,228.70	..	311.16	1,027.33	411.80	336.53	134.81	71.89	472.17	209.63	2.618.59
at Dec. 31st, 1961	205.34	285.31	140.51	1,223.28	100.00	380.42	1,535.06	277,54	313.65	118.52	150.82	401.87	260.73	3.211.42

ludes all rebates, whether for E.I.C. or Commonwealth fees.
ludes general printing, meeting notices, stationery, postage, telephone and telegrams.
ludes rental of rooms, projectors, operators, slides, dinners, entertainment, social functions, etc. for both general special.
ludes speakers, councillors, or branch officers.
ludes all publications.

hip Totals

	Total	Hon. Members	Life Members	Members	Associate Members	Students	Affiliates
[illegible]	21,300	35	681	11 383	4,069	5,074	8
Unknown	202		—	23	56	123	—
anch Members	1,099	10	68	711	224	82	4
and Total	22,601	45	749	12 117	4,349	5,279	[illegible]

BRANCHES	Fredericton	Halifax	Hamilton	Huronia	Kingston	Kitchener	Kootenay	Lakehead	Lethbridge	London	Lower St. Lawrence	Moncton	Montreal
MEMBERSHIP													
Hon. Members	1	1	..	..	1	..	..	..	1	1	..	..	8
Life Members	6	23	21	2	10	8	1	5	7	11	..	5	173
Members	114	402	319	32	119	104	56	83	51	167	21	74	2,615
Associate Members	86	125	88	16	81	23	19	38	21	79	18	32	980
Students	168	191	69	15	130	90	14	14	11	171	16	52	1,334
Affiliates	..	..	2	1	..	..	1	3	..	..	..	1	14
Total	375	742	499	66	341	225	91	143	91	429	55	164	5,124
FINANCIAL STATEMENT													
Receipts													
Rebates from E.I.C. Hq. (1)	406.64	465.42	1,278.50	205.18	535.75	575.18	219.85	289.10	34.50	668.32	111.95	284.30	9,921.49
Remittances from Prof. Assns.	..	972.40	..	..	..	..	..	..	175.31	..	..	..	..
Branch Affiliate Dues	..	..	102.00	..	86.00	39.25	78.00	..	107.55	..	..	40.00	18.00
Interest	8.48	12.71	77.74	..	..	8.27	..	..	..	..	..	38.97	290.00
Miscellaneous	871,98	1,090.69	..	..	272.50	278.75	283.41	390.53	8.00	1,202.73	300.00	551.94	2,785.83
Total Receipts	1,287.10	2,541.22	1,458.24	205.18	894.25	901.45	581.26	679.63	325.36	1,871.05	411.95	915.21	13,015.32
Disbursements													
Printing and Communications (2)	82.25	470.41	922.51	15.55	75.27	40.62	41.45	76.94	122.59	475.09	30.62	30.96	4,116.75
Meeting Expenses (3)	1,036.37	1,919.11	475.79	47.95	579.17	471.30	593.61	414.89	72.64	1,568.32	293.75	669.79	5,069.38
Honorariums and Steno Services	50.00	180.00	75.00	11.54	..	34.95	40.13	..	75.00	..	..	50.00	907.50
Travelling Expense (4)	50.00	100.00	75.00	..	..	10.00	..	..	..	303.40	..	..	..
Subscriptions (5)	..	..	24.00	..	28.15	..	..	12.00	8.00	..	..	24.15	..
Special Expense	19.36	89.48	265.47	..	122.79	73.50	..	117.30	76.95	1.00	10.00	71.32	2,311.08
Total Disbursements	1,237.98	2,759.00	1,837.77	75.04	805.38	630.37	675.19	621.13	355.18	2,347.81	334.37	846.22	12,404.71
Surplus	49.12	..	..	130.14	88.87	271.08	..	58.50	..	..	77.58	68.99	610.61
Deficit	..	217.78	379.53	..	..	..	93.93	..	29.82	476.76	..	..	..
Balance at Dec. 31st, 1960	443.24	1,178.63	925.01	361.36	973.34	448.64	549.56	62.08	372.03	985.94	48.99	997.31	3,733.47
Balance at Dec. 31st, 1961	492.36	960.85	545.48	491.50	1,062.21	719.72	455.63	120.58	342.21	509.18	126.57	1,066.30	4,344.08

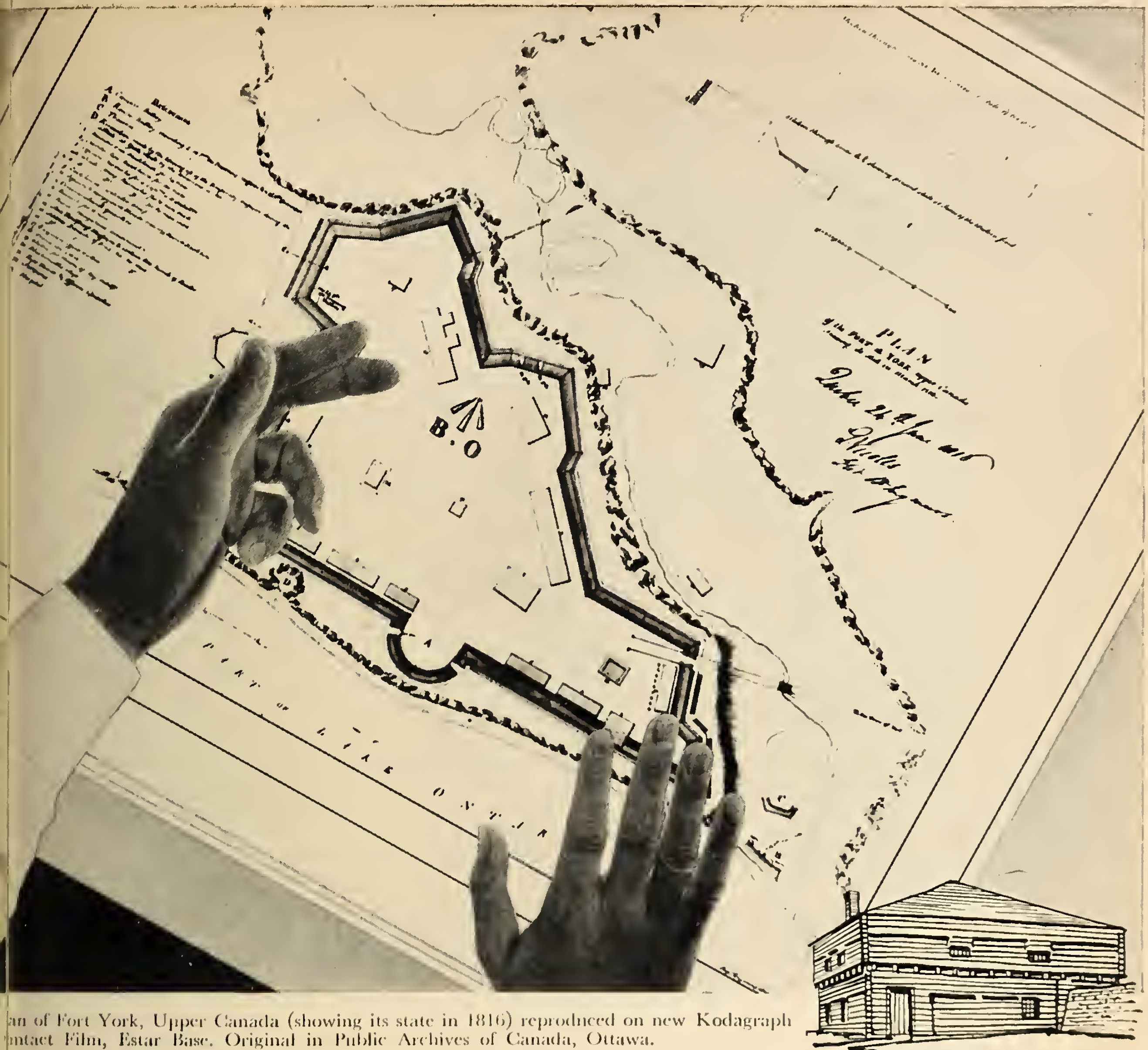
(1) Includes all rebates, whether for E.I.C. or Commonwealth fees.
(2) Includes general printing, meeting notices, stationery, postage, telephone and telegrams.
(3) Includes rental of rooms, projectors, operators, slides, dinners, entertainment, social functions, etc. for both general and special.
(4) Includes speakers, councillors, or branch officers.
(5) Includes all publications.

BRANCHES	Niagara Peninsula	Nipissing and Upper Ottawa	North Eastern Ontario	Northern New Brunswick	Northern Nova Scotia	North Shore Lower St. Lawrence	Oakville	Ottawa	Peterborough	Port Credit	Port Hope	Prince Edward Island	Quebec	Richmond Hill
MEMBERSHIP														
lembers	1	..	..	..	1	..	..	3	1	..	..	..	2	..
embers	20	1	..	..	2	..	2	67	10	1	1	2	21	2
rs	172	48	22	33	29	55	68	627	121	75	22	20	228	46
te Members	52	26	9	27	8	26	9	212	17	10	5	19	110	5
ts	34	14	11	16	23	2	7	247	16	5	4	39	316	16
es	2	1	..	..	..	1	..	2	..	..	..	..	..	..
l	281	90	42	76	63	84	86	1,158	165	91	32	80	677	69
ANCIAL STATEMENT														
s from E.I.C. Hq. (1)	726.42	289.00	130.75	31.50	51.60	256.60	295.70	2,468.36	445.01	306.90	115.20	48.70	740.25	50.00
ances from Prof. Assns	..	..	..	40.00	96.90	..	..	..	..	..	..	..		..
Affiliate Dues	..	20.00	..	..	..	..	..	..	42.00	..	..	..		..
t	..	..	..	1.11	..	..	.88	16.24	..	..	..	..		..
aneous	432.73	511.62	..	271.75	..	692.16	2.00	1,850.70	6.23	..	13.85	..	..	
l Receipts	1,159.15	820.62	130.75	344.36	148.50	948.76	298.58	4,335.30	493.24	306.90	129.05	48.70	740.25	50.00
ements														
g and Communications (2)	341.44	37.19	..	37.55	2.30	..	38.08	902.80	40.26	67.29	..	..	162.56	..
g Expenses (3)	535.85	980.29	63.65	236.50	..	681.88	63.00	2,408.24	375.18	34.90	143.38	..	395.78	21.33
riums and Steno Services	81.55	..	..	..	..	..	..	100.00	..	..	..	235.00	200.00	
ling Expense (4)	136.78	..	..	..	..	..	..	..	..	..	..	..		
iptions (5)	..	8.00	..	..	..	..	..	..	..	..	..	..		
Expense	..	..	55.45	211.50	..	1.00	..	125.00	150.49	2.00	..	..	15.35	4.00
l Disbursements	1,095.62	1,025.48	119.10	485.55	2.30	682.88	101.08	3,536.04	565.93	104.19	143.38	235.00	773.69	25.33
lus	63.53	..	11.65	..	146.20	265.88	197.50	799.26	..	202.71	..			24.67
it	..	201.86	..	141.19	..	..	..	..	72.69		14.33	186.30	33.44	
e at Dec. 31st, 1960	747.59	507.62	400.56	282.56	291.05	233.46	44.24	1,305.04	426.21	..	61.56	(24.70)	458.19	
e at Dec. 31st, 1961	811.12	302.76	412.21	141.37	437.25	499.34	241.74	2,104.30	353.52	202.71	47.23	(211.00)	424.75	24.67

ludes all rebates, whether for E.I.C. or Commonwealth fees.
ludes general printing, meeting notices, stationery, postage, telephone and telegrams.
ludes rental of rooms, projectors, operators, slides, dinners, entertainment, social functions, etc., for both general
l special.
ludes speakers, councillors, or branch officers.
ludes all publications.

BRANCHES	Saguenay	Saint John	St. Maurice Valley	Sarnia	Saskatchewan	Sault Ste. Marie	Sudbury	Toronto	Vancouver	Vancouver Island	Whitby	Winnipeg
MEMBERSHIP												
Hon. Members	..	..	..	..	2	..	..	5	2	1	..	1
Life Members	1	6	4	1	11	3	2	84	39	38	2	25
Members	134	88	124	138	776	34	71	1,208	555	127	45	494
Associate Members	56	54	63	23	281	13	24	367	151	28	11	252
Students	31	25	71	14	216	8	15	243	280	60	8	341
Affiliates	..	1	..	..	..	..	3	7	3	1	..	2
Total	222	174	262	176	1,286	58	115	1,914	1,030	255	66	1,115
FINANCIAL STATEMENT												
Receipts												
Rebates from E.I.C. Hq. (1)	693.76	275.83	454.40	521.96	171.00	212.68	569.57	5,108.69	2,232.10	518.61	50.00	507.33
Remittances from Prof. Assns	53.80	..	..	16.50	1,578.86	8.00	..	..	..	..	..	1,208.60
Branch Affiliate Dues	..	76.00	..	4.00	..	27.00	84.50	20.00	..	..	..	224.00
Interest	5.18	..	..	11.33	..	..	..	84.71	47.20	..	..	125.25
Miscellaneous	1,377.91	1,469.07	236.50	70.41	..	22.58	1,517.45	2,585.56	260.46	..	..	74.25
Total Receipts	2,130.65	1,820.90	690.90	624.20	1,749.86	270.26	2,171.52	7,798.96	2,539.76	518.61	50.00	2,139.43
Disbursements												
Printing and Communications (2)	88.85	172.99	219.90	..	275.68	13.80	263.80	2,044.76	1,282.82	89.25	9.76	1,124.01
Meeting Expenses (3)	1,625.70	1,842.44	696.34	158.40	460.62	60.74	1,829.99	2,908.95	1,196.52	171.54	27.20	354.05
Honorariums and Steno Services	60.00	40.00	..	111.73	450.00	50.00	50.00	225.00	146.19	56.00	..	370.25
Travelling Expense (4)	..	..	10.00	198.60	392.56	..	18.65	150.00	63.70	..	..	..
Subscriptions (5)	..	16.30	..	..	..	..	32.00	..	60.00	..	..	237.00
Special Expense	38.00	5.15	5.00	..	2,000.00	17.09	20.00	689.28	100.00	120.87	..	136.79
Total Disbursements	1,812.55	2,076.88	931.24	468.73	3,578.86	141.63	2,214.44	6,017.99	2,849.23	437.66	36.96	2,222.10
Surplus	318.10	..	..	155.47	..	128.63	..	1,780.97	..	80.95	13.04	..
Deficit	..	255.98	240.34	..	1,829.00	..	42.92	..	309.47	..	..	82.67
Balance at Dec. 31st, 1960	757.91	841.54	238.18	992.84	2,461.89	268.12	364.93	4,146.76	2,405.67	172.03	..	705.94
Balance at Dec. 31st, 1961	1,076.01	585.56	(2.16)	1,148.31	632.89	396.75	322.01	5,927.73	2,096.20	252.98	13.04	623.27

(1) Includes all rebates, whether for E.I.C. or Commonwealth fees.
(2) Includes general printing, meeting notices, stationery, postage, telephone and telegrams.
(3) Includes rental of rooms, projectors, operators, slides, dinners, entertainment, social functions, etc. for both general and special.
(4) Includes speakers, councillors, or branch officers.
(5) Includes all publications.



an of Fort York, Upper Canada (showing its state in 1816) reproduced on new Kodagraph ontact Film, Estar Base. Original in Public Archives of Canada, Ottawa.

New way to restore old drawings!

New Kodagraph Contact Film, Estar Base, transforms old, soiled, or weak-lined drawings into top-quality intermediates which will stand up under punishment in print-making machines and on drafting boards.

Bound to be a favorite in darkroom as well as drafting room, this new Kodagraph Contact Film lets you produce same-size intermediates with new convenience. Simply expose with low-cost paper negative (or film negative) in standard contact printer. Process with either paper or litho developer. Exceptionally wide latitude — in exposure and development — all but ends make-overs.

See this new Kodagraph Film — and the others in the new Estar Base line: Kodagraph Autopositive Film, Kodagraph Projection Film.

All combine reliable Kodak emulsions on the new Estar Base — highly translucent, durable, and dimensionally stable, with excellent matte surface on both sides for easy drafting. Available in standard drawing sheet sizes and in rolls up to 52 inches wide. Call your local Kodagraph Dealer, or write Canadian Kodak Co., Limited, Toronto 15, Ontario.

NEW!

Kodagraph

REPRODUCTION FILMS

. . . for best line-for-line reproduction

Kodak

Library Notes

Prepared by the Library, The Engineering Institute of Canada

Book notes marked by an asterisk have been provided through the courtesy of The Engineering Societies Library in New York.

A GUIDE TO FORTRAN PROGRAMMING.

For those wanting to use computers in the solution of problems in science and engineering, this guide shows how by using Fortran (Formula Translation) it is not necessary to learn all the details of computer operation. It was developed primarily for the IBM 704, but can be used for other computers also. The book covers arithmetic statements, input and output statements, transfer of control, subscripted variables, the Do statement, and functions and specification statements. A final chapter outlines eight specific cases of FORTRAN use. (D. D. McCracken. New York, Wiley, 1961. 88p., $2.95.)

*PLASTIC FLOW AND FRACTURE IN SOLIDS.

A study of the propagation, growth, and decay of discontinuities in solids, including the theory of characteristic surfaces and the spread of plastic into elastic regions. Individual chapters cover basic invariants in the mechanics of continuous media, equations of continuity and motion, conditions of compatibility, waves in elastic media, perfectly plastic solids, equilibrium theory of Luders bands, characteristic surfaces and wave propagation, and instability and fracture. (T. Y. Thomas. New York, Academic, 1961. 267p., $8.50.)

*SIMPLIFIED MECHANICS AND STRENGTH OF MATERIALS, 2ND. ED.

An elementary work which provides basic information in the field of mechanics and strength of materials. Using a minimum of advanced mathematics, a large portion of this book is devoted to illustrative examples of a practical nature. Besides changes in working stresses, certain additions have been made in this edition. They include the investigation of reactions, shear, and bending moments for continuous beams with concentrated loads; the use of structural aluminum; the design of solid wood columns to conform with current building-code requirements; the design of spaced columns; and the use of high strength bolts. (Harry Parker. New York, Wiley, 1961. 285p., $6.75.)

NUMERICAL METHODS FOR HIGH SPEED COMPUTERS.

In order to make the most effective use of high speed electronic computers, it is often necessary to develop new methods of solving complicated problems, to replace the traditional mathematical methods. The author, in charge of the Digital Computer Group at the U.K. Atomic Energy Establishment has collected these new methods, which are applicable to most modern computers. The first two chapters discuss numerical methods and the related problems, and methods for evaluating functions. The next three chapters discuss problems which can be solved as ordinary differential equations, as partial differential equations, and by matrix methods. A final chapter covers various miscellaneous methods. There is a useful bibliography. (G. N. Lance. Toronto, British Book, 1960, 166p., $9.50.)

*SCIENCE IN SPACE.

The achievements of space science from the launching of the first Soviet Sputnik to the present time are reviewed. Coverage is given to rocket research in the upper atmosphere, how space vehicles can increase man's knowledge of the Earth, experiments using space vehicles, prospects of life beyond the Earth, the use of earth satellites for weather forecasting, and the problem of backward and forward contamination. In addition electromagnetic fields, particles, and radiations in interplanetary space, auroral theory, and the magnetic fields of Earth, sun and space are discussed. (Ed. L. V. Berkner and Hugh Odishaw, Toronto, McGraw-Hill, 1961. 458p., $8.00.)

THE ENGINEERING INSTITUTE LIBRARY

The publications mentioned in these notes are now available in the Library, and may be borrowed by members of the Institute. Two items may be borrowed at one time for a period of two weeks, excluding time in transit.

Library hours are: Monday to Friday: 9 a.m. to 5 p.m.; Saturdays: 9 a.m. to 12 noon. All requests and enquiries should be addressed to the Librarian at 2050 Mansfield Street, Montreal.

FREQUENCY MODULATION THEORY: APPLICATION TO MICROWAVE LINKS.

The authors, both with the Frencl Compagnie Générale de T.S.F., have i this volume collected a great deal of in formation on frequency modulatio theory and radio beams which previousl was scattered throughout the literature

The first section is concerned wit wave propagation, including frequenc curves and results for optical paths an transmissions beyond the horizon. Th second section discusses the fundament concepts of frequency modulated system and the distortion and noise problem The three remaining parts cover propa gation distortion, the transmission b radio beams of multiplex telephonic o television programme signals, and th equipment required for microwave lin transmission. Bibliographies are include in each section. (Jacques Fagot an Philippe Magne. London, Pergamo 1961. 488p., $15.00.)

*ELECTRICAL ESTIMATING, 3RD. ED.

This volume ranges in its coverag from the selection and training of elec trical estimators to the proper use o estimating tools, the cost of preliminar estimates, and the preparation of fin bid shuts. Included are sample estimate methods of checking estimates, and th preparation of labor-cost units. It als shows how to figure markups, and pro vides information useful in solving prob lems relating to appraisal, cost account ing, and job scheduling. (Ray Ashley Toronto, McGraw-Hill, 1961. 437p $11.50.)

*THEORY OF HYDRODYNAMIC LUBRICATION.

By applying the general principles o fluid flow to bearing operation, th authors formulate the differential equa tions of lubrication, including energ and elasticity considerations. They pre sent techniques for solving these equa tions either analytically or by analog an digital computers. These equations pro vide a basis for the design and solutio of specific bearing problems. Severa topics are presented for the first tim such as hydrodynamic instability, hydro dynamics of rolling elements, inerti and turbulence effects, non-Newtonia fluids, and an extension of the classica theory. (Oscar Pinkus and Beno Stern light. Toronto, McGraw-Hill, 1961 465p., $17.25.)

(Continued on page 162)

(Continued from page 110)

Eastern Townships

J. P. Champagne, M.E.I.C.
Correspondent

On the evening of February 23, the Branch was host to the President of the Corporation of Professional Engineers of Quebec, Arnold J. Groleau. Mr. Groleau discussed at length various topics such as Confederation, the salaried engineer, the practice of engineering by limited companies and a new bill to be presented to the Quebec legislature. An animated question-and-answer period followed the talk. Some 60 engineers and students from the University of Sherbrooke participated in this even. Earlier in the day, Mr. Groleau visited the Faculty of Sciences to preside at the ritual of the calling of an engineer where some 39 students were admitted to the Corporation.

Estevan Section

D. P. Lesiuk, M.E.I.C.
Correspondent

J. Stephenson, Superintendent of the Boundary Dam Generating Station, Estevan, Sask., in his talk to the Branch's February 13 meeting, discussed how the demand for electrical power in Saskatchewan is met by the addition of power generating facilities. He also discussed the technical difficulties encountered at the Boundary Dam Generating Station, and the methods by which they are being solved. Mr. Stephenson was assisted in his address by Bert Hamilton, an engineer at the Boundary Dam.

Members of the Branch voted in favor of an annual award scholarship to be presented to a graduating student from Estevan Collegiate entering Engineering. The conditions governing the award were discussed. Engineers from the Branch would speak to students at Estevan Collegiate regarding opportunities in Engineering.

G. Ursenbach, Chairman of the Branch was selected to represent the members at the annual meeting of the A.P.E.S. on February 23 in Regina. An officers' meeting was held February 14 at which a speaker explained the eligibility of technicians in the A.P.E.S. An address regarding Engineering careers was given to grade XII students by K. de Jong.

London

W. L. Thompson, M.E.I.C.
Correspondent

Thirty members attended the January 16 meeting of the Branch. A very interesting talk on Traffic Engineering was presented by John R. Crosby, head of the traffic engineering department at M. M. Dillon and Company on Toronto. Mr. Crosby outlined an extensive program of surveys and studies being used to improve street and highway routes and safety. He said research is now under way to relieve the motor vehicle driver of some of the problems of driving. These range from seemingly simple solutions of standardizing of the position of tail, stop and turn signals to a complex vehicle guidance system which guides the vehicle as if it were on a fixed rail network. Mr. Crosby said that convenient and economic transportation was not necessarily synonymous with safe transportation. There is a certain amount of risk in all forms of traffic operations as we know them today, but we can take heart in the advances made in automotive transportation since its advent at the turn of the century. Without these advances, he said, the annual death, injury and property damage toll would have been several times higher. He said that safety-expert warnings of increased accident rates were true, but "during the last 25 years, the accident frequency has declined steadily". A question-and-answer period followed this talk.

On Friday, February 16, the Branch co-sponsored a dinner dance at the Hotel London. Some 200 guests attended. Following a reception where guests were received by G. T. Fenwick, Chairman of the Branch, and Mrs. Fenwick, and K. Clawson, Chairman of the A.P.E.C. Branch, and Mrs. Clawson, dinner was served and dancing was enjoyed for the remainder of the evening.

On February 20, a joint meeting of the American Institute of Electrical Engineers and the Branch was held at the Reserve Officers' Mess, Wolseley Barracks, and was attended by some 80 members. The guest speaker was H. Lee Briggs, member of the National Energy Board, Ottawa. He presented an illustrated lecture entitled "Economics of Long Distance Direct Current Transmission".

(Continued on page 158)

Business and Industrial Briefs

Appointments and Transfers

L. F. Kilmarx has been appointed to the newly created position of regional manager of the Ontario district of Air Reduction Canada Ltd. This position was created for better co-ordination of the marketing activities of Airco's Welding and Carbon Dioxide operations. Mr. Kilmarx brings to his new position a wide experience gained from long association with Air Reduction in the United States and extensive knowledge of the metal working and gas fields. Until his recent appointment, he was a management consultant.

John D. Leitch, Chairman, Maple Leaf Mills Limited, has been appointed to the Board of Directors of Massey-Ferguson Limited. **Lawrence H. Pomeroy** has been appointed director of marketing for Massey-Ferguson's North American Operations. Mr. Pomeroy, who held a similar post in the company's United Kingdom Operations, succeeds **George S. Gordon**, who has been on special assignment as director marketing, North America, and now returns to the company's world-wide marketing office in Toronto.

L. S. Todd has been appointed central region manager of I-T-E Circuit Breaker (Canada) Limited, Port Credit, Ont. Mr. Todd, a graduate of the University of Toronto, has had wide experience in the electrical field and will be responsible for the sale of the complete line of electrical equipment manufactured by the company's Eastern Power Devices Division and Bulldog Electric Products Division.

R. S. Dudley has been appointed manager of special projects at the Polymer Corporation Limited in Sarnia. Mr. Dudley joined Polymer as a product engineer in the Copolymer Plant in 1951 after graduating from U.B.C., and became a process design engineer in 1953. In 1955 he was promoted to supervisor of the product development section. In 1959 he became supervisor of the process control section of the rubber department and remained in that position for two years. Until his recent appointment, he was in the products and development department of economics and development.

George M. Bailey has been appointed general manager of the Canadian Division of the Yale & Towne Manufacturing Company in St. Catharines, Ont. Mr. Bailey has had wide experience in the company's production and marketing operations since he joined the company in 1947 as business manager of its former appliance division. Since 1953 he has been executive assistant to L. J. Pantas, vice-president of lock and hardware in the United States.

The Abitibi Corporation has announced the appointment of **Alan B. Cook** as vice-president of Sales with headquarters at Detroit. Mr. Cook was formerly general sales manager and is a member of the Corporation's Board of Directors.

A. J. Hutcheon has been appointed product manager, frequency control quartz crystals, at Philips Electronic Equipment Ltd., Toronto. Mr. Hutcheon, who is also product manager, electronic components, has been with Philips for a number of years. Before joining Philips, he was chief engineer in charge of design and application engineering at Ward Leonard of Canada Ltd., and before that, assistant chief engineer with Canadian Line Materials Ltd.

C. F. Way has been appointed sales manager, data processing systems at Burroughs Business Machines Ltd. Mr. Way joined Burroughs in 1953 as a sales representative in Vancouver. In 1956 he became zone manager and 1958 manager of the company's branch in Regina, Sask.

Irwin H. Groom has been appointed gei eral manager of Dominion Tar's subsic iary, Sifto Salt Limited. Mr. Groo joined the company two years ago and a marketing specialist. He had previous spent 14 years in chemical sales ar marketing work following his graduatic from McGill. **Walter R. Lawson** becom development director for a group of D minion Tar's chemical companies. The include Sifto Salt Limited; Canada Cr osoting Co., Ltd.; Chemical Develo ments of Canada Limited; the Coal T Products Division and the Lime Divisio In his new position, Mr. Lawson will l responsible for developing new processe products, enterprises and markets in tl chemicals field. He joined Dominion T in 1945.

William D. Davidson, a principal wi the Payne-Ross Limited, manageme consultants, has been appointed associa director of the company's Ontario div sion with headquarters in Toronto. M Davidson's business experience includ 10 years in industrial engineering ar financial analysis with York Gears Ltd Philips Electronics Industries Ltd. an Massey-Ferguson Ltd. In addition, he h had wide experience in both industri and municipal organizations througho Canada.

C. H. Swanson has been appointed assis ant vice-president and manager of pr duction at the Josam Products Limite in Toronto, Ont. Mr. Swanson has bee with the Company for 23 years.

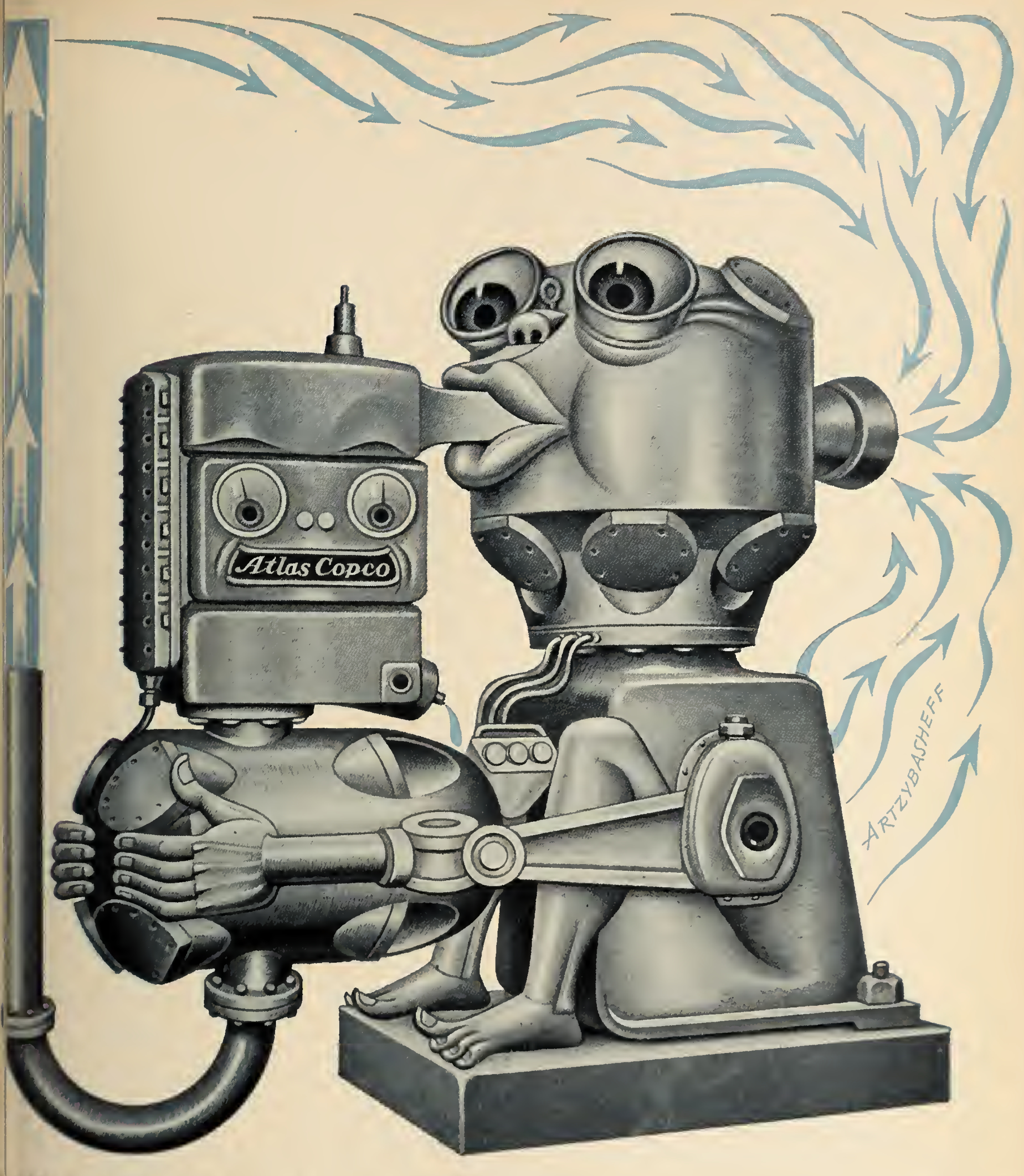
Developments

Information contained in this section has been obtained from press release Mention of products and services does not imply endorsement by the Institut

CANADIAN INDUSTRIES LIMITED has announced the construction of a plant to manufacture liquid mercurial seed-treatments and related products at the C-I-L works at Calgary. The new plant, situated where suitable land, services, technical facilities and supervision are already available, will be in operation by autumn, 1962.

THE SCARBOROUGH PLANT c Honeywell Controls has announced th addition of 43,040 square feet to i facilities. Construction is to begin i April with completion scheduled fc early August. This addition brings th total area occupied by the Scarboroug plant to 191,040 sq. ft.

(Continued on page 163)


Atlas Copco
ARTZYBASHEFF

(Continued from page 155)

Niagara Peninsula

B. H. Chick, M.E.I.C.
Correspondent

A. E. Berry, general manager, Ontario Water Resources Commission, was the guest speaker at a meeting held in St. Catharines on February 20. Approximately 100 engineers heard Mr. Berry's talk on Water Resources management in Ontario.

On January 18, in Welland, Dr. K. F. Tupper, Hon. M.E.I.C., President, Ewbank, Tupper Associates Ltd., presented his paper dealing with the National Aeronautics Establishment's Wind Tunnel which appeared in the August 1961 issue of the Engineering Journal. Dr. Tupper was assisted by P. B. Dilworth, M.E.I.C., President, Dilworth, Secord, Meagher and Associates, and by L. A. Jenkins, M.E.I.C., project engineer for the electrical aspects of the wind tunnel.

P. G. Wilson, technical field representative for the Plywood Manufacturers Association of British Columbia, was the guest speaker at the Branch's December 14, 1961 meeting in St. Catharines. He discussed the physical properties, design characteristics and special applications of laminated fir plywood as a construction material.

November 10, 1961, was the date of a visit by President Ballard who discussed Confederation at the general meeting of the Branch. Dr. and Mrs. Ballard were entertained at a dinner given by the Branch executive.

During October 1961, the Branch held a tour through the Page Hersey Tubes Limited plant in Welland, Ont.

Nipissing and Upper Ottawa

J. S. Cooper, M.E.I.C.
Correspondent

The Branch held a dinner meeting February 14 at White Oaks Inn where the guest speaker was C. H. Cunningham, District Superintendent, Trans-Canada Pipe Lines Ltd., North Bay, Ont. Mr. Cunningham was introduced by J. W. Millar, and began with a brief introduction to the film, "Natural Gas Goes East". This full color film illustrated vividly the construction of the Trans-Canada Natural Gas Pipe Line from the Saskatchewan-Manitoba boundary to Southern Ontario. This line is 2290 miles long and was completed in about two years at a cost of $375,000,000. There are 184 water crossings and 530 miles of rock excavation through Northern Ontario's Pre-Cambrian Shield. A 45-minute question period followed the showing of this film, and Mr. Cunningham was thanked by J. Rosborough, of Temiskaming.

The Branch members will sponsor a dinner and meeting at Students' Night March 7. The guest speaker will be R. L. Beck, of Canadian General Electric Co., Ltd., whose subject will be, "The Fuel Cell".

Quebec

Rene Rioux, M.E.I.C.
Correspondent

Le 14 février, à l'occasion de la semaine nationale de l'électricité, le chapitre de Québec de l'Institut Canadien des Ingénieurs, conjointment avec l'American Institute of Electrical Engineers, présentait à ses membres, à la nouvelle faculté des sciences de la Cité Universitaire, 2 conférenciers.

M. T. Wildi fit part à son auditoire du nouveau curriculum du département de génie électrique de l'Université Laval.

M. Oscar Dorval, M.E.I.C., traita de certains aspects électriques des nouveaux pavillons de la faculté des sciences.

La soirée s'est terminée par un visite des nouveaux édifices, sous la direction de M. Dorval qui nous a fourni tous le renseignements nécessaires sur les installations mécaniques et électriques dont il a pourvu ces nouveaux pavillons à titre d'ingénieur-conseil.

Lundi, le 19 février, la section des étudiants de la faculté des sciences recevait comme conférencier M. Henri F. Béique, M.E.I.C., président de la compagnie Quebec Power.

Au cours de sa conférence, M. Béique a su, par ses remarques et ses conseils profiter de sa vaste expérience les étudiants qui bientôt joindront les rangs de notre profession.

M. Georges Tremblay, président de la section étudiante, avait profité de la circonstance pour inviter quelques membres senior de la section de Québec.

La réunion s'est terminée par un coquetel au cours duquel les étudiants et les invités ont pu fraterniser et discuter de différents problèmes concernant l'avancement de la profession et le rayonnement de l'institut.

University of Western Ontario

David Fader, S.E.I.C.
Correspondent

The 1962 Executive for the Branch was elected at a meeting on January 30. David Fader was elected Chairman, William Dukelow, Vice-Chairman and Arthur Huber as Secretary-Treasurer.

W. K. Clawson, Vice-President, M. M. Dillon and Co. Ltd., Consulting Engineers, London, was the guest speaker at the Branch's February 27 meeting. The title of his talk was Municipal Engineering. Mr. Clawson gave a general outline of this field, indicating differences between small town municipal engineers and those in cities. He discussed several plans for future projects and gave reports of projects already begun. A project of particular interest was the Spadina Avenue Expressway in Toronto.

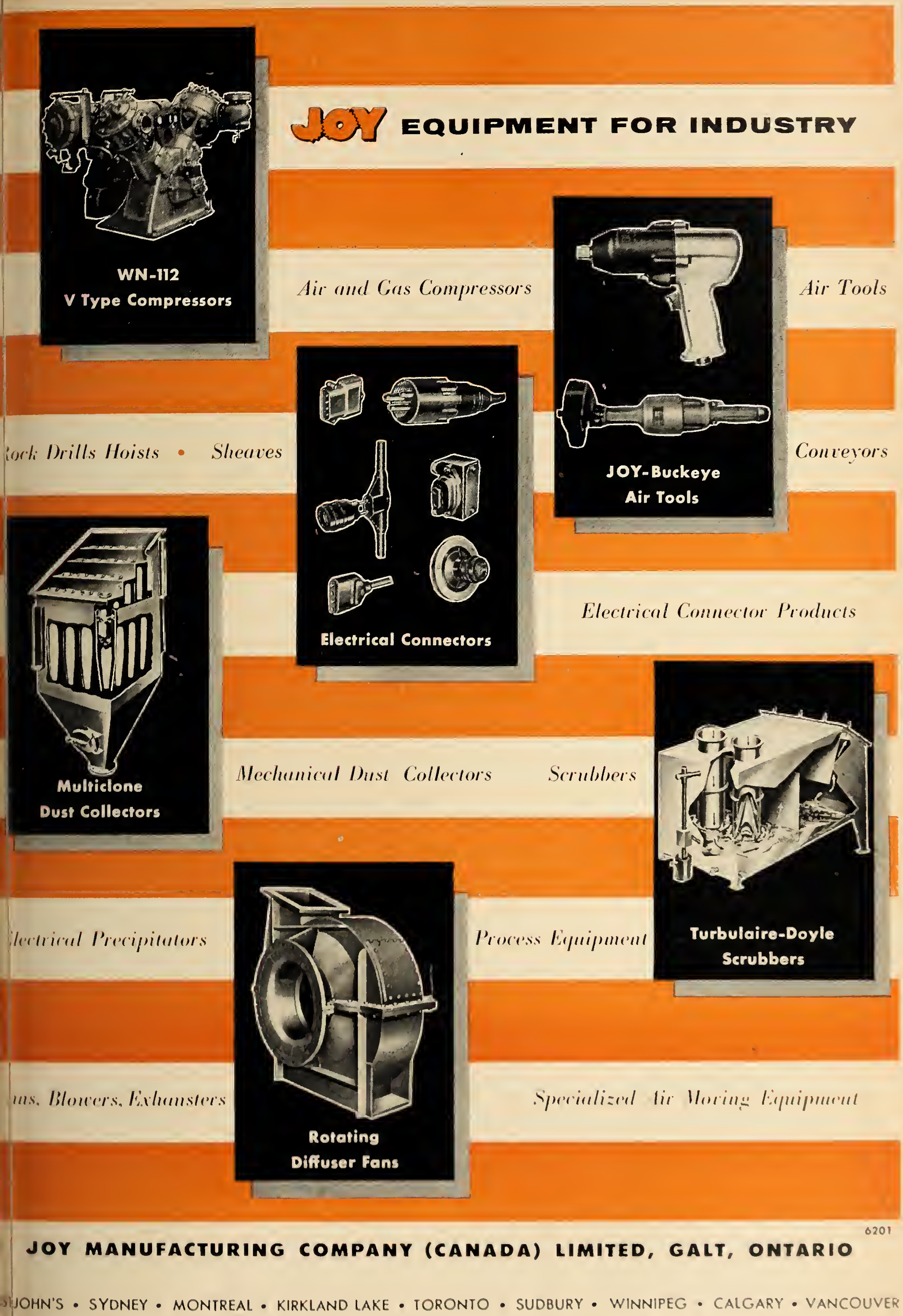
Winnipeg

P. A. Brett, M.E.I.C.
Correspondent

Winnipeg is notorious for its frigid and confining winters and this past one has been a near-record. In spite of the weather, attendance at the Electrical Section Technical meetings has been excellent and speaks well for the quality of the papers delivered. An outline of the winter's activities follows.

On November 2, W. M. Pearce, of the Interprovincial Pipe Line Company described the electrical aspects of the design and construction of electric pump stations for trunk line crude oil service.

(Continued on page 160)


JOY EQUIPMENT FOR INDUSTRY
WN-112
V Type Compressors
Air and Gas Compressors
Air Tools
JOY-Buckeye
Air Tools
Rock Drills Hoists • Sheaves
Conveyors
Electrical Connectors
Electrical Connector Products
Multiclone
Dust Collectors
Mechanical Dust Collectors
Scrubbers
Turbulaire-Doyle
Scrubbers
Electrical Precipitators
Process Equipment
Fans, Blowers, Exhausters
Rotating
Diffuser Fans
Specialized Air Moving Equipment
6201
JOY MANUFACTURING COMPANY (CANADA) LIMITED, GALT, ONTARIO
ST. JOHN'S • SYDNEY • MONTREAL • KIRKLAND LAKE • TORONTO • SUDBURY • WINNIPEG • CALGARY • VANCOUVER

(Continued from page 158)

The pros and cons of electric drive were analysed. The problems met with in the operation of remote pumping stations were detailed along with an interesting description of telemetering and supervisory control equipment used. The very large distances spanned by the crude oil pipe lines, in this case from Edmonton to Sarnia, alone create numerous difficulties. An active discussion period followed.

The Annual dinner dance of the Branch's Electrical Section was held at the Fort Garry Hotel on November 18 and was thoroughly enjoyed by 280 members and guests.

Those who attended the Technical Section on December 7 were treated to an interesting and at times startling demonstration at the High Voltage Laboratory of the University of Manitoba. This followed a dinner meeting at the Voyageur Motel. Unfortunately, Professor J. P. C. McMath, originally scheduled to talk on the various aspects of the High Voltage Laboratory, was taken ill. However members who were involved in the initial planning stages and fund raising were called upon. They gave some idea of background and anecdotes concerning the Dean E. P. Fetherstonaugh Memorial High Voltage Laboratory. The demonstrations were ably carried out at the University by Tom White, pinch-hitting for Professor McMath.

At a dinner meeting held at the Marion Hotel in St. Boniface on January 11, officers for the 1962-63 term were elected. They are: T. L. Woodhall, Chairman; D. C. Bryden, Past Chairman; J. P. C. McMath, Vice-Chairman; Thos. Erskine and E. F. MacKenzie, Executive Members; P. A. Brett, Papers Chairman. The Secretary and Recorder to be appointed at a later date.

G. A. Muir of the Manitoba Telephone System, both enlightened and enlivened the membership on February 1 with a talk on future developments of telephone communication systems. The enlivening arose out of several anecdotes related by the speaker arising out of his recent trip to Geneva to attend the International Telephone Union Conference. Some of the subjects covered were submarine cables, land lines, microwaves, both line-of-site and coaxial, scatter systems, standardizing problems arising out of international point to point dialing and communications via satellites. A description of three satellite projects; "Echo", "Vanguard", and "Telstar" was given as well as an actual demonstration with model equipment from the Bell Telephone Laboratories.

On March 1 a dinner meeting was held at the Pembina Hotel. The latest developments in wire and cable insulations were outlined by D. Ashenden of Phillips Electrical Co. Ltd. In addition to the technical aspects of polyethylene and butyl rubber insulation materials, the speaker looked into the possible future use of new materials not now being utilized. Samples of various insulation materials were available for viewing by the membership. The formal talk was followed by a question-and-answer period. EIC

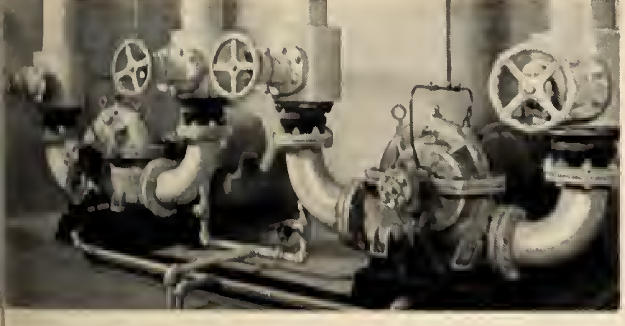
NEW "SHOWPLACE" OF MODERN OFFICE BUILDING DESIGN

Some people like it hot – some like it cool. The new, 11-storey $3,200,000 Professional Building in Edmonton can satisfy both tastes. Self-adjusting heating and air conditioning levels for individual offices are among its many advanced features. The accent is on beauty and convenience in work and reception areas . . . on the utmost dependability in essential services – exemplified by the choice of Jenkins valves for the plumbing, heating and air conditioning systems. No matter how advanced or complex the installation, you can always count on Jenkins valves for long-term, efficient service. Jenkins Bros., Limited, Lachine, Que.

PROFESSIONAL BUILDING, EDMONTON, ALTA.

General Contractor: Perini (Western) Limited
Mechanical Contractor: Lockerbie & Hole Western Limited
Mechanical & Electrical Consulting Engineers: Crowther, MacKay and Associates
Architects: Gerald Hamilton and Associates
Assoc. Architects: Sinclair, Skakun, Naito

kins Iron Body Gate Valves on the Chilled Water Circulating Pumps.



SOLD BY LEADING DISTRIBUTORS EVERYWHERE

JENKINS VALVES

LOOK FOR THE JENKINS DIAMOND

TRADE JENKINS MARK

• Library Notes

(Continued from page 144)

*PRINCIPLES OF REFRIGERATION.

The design, installation, and maintenance of refrigerating and air conditioning equipment is discussed in a comprehensive fashion. Throughout the text emphasis is placed upon the cyclic nature of the refrigeration system, and each part of the system is carefully examined in relation to the whole. Theory and practice are correlated through the use of manufacturer's catalog data and sample problems. To this end pertinent catalog data is included. Despite a rigorous treatment of the thermodynamics of the cycle, application of the calculus is not required, nor is physics an extensive background in physics and thermodynamics presupposed. (R. J. Dossat. New York, Wiley, 1961. 544p., $12.00.)

*ANALYSIS OF NONLINEAR CONTROL SYSTEMS.

The essential mathematical tools necessary for solving the analysis problems that arise in the design of nonlinear control systems are presented. The largest portion of the book is devoted to two subjects: a general theory of "quasi-linear" systems for the description of periodic and random input behaviour, and topological phase space techniqu for the description of transient behavio Throughout the text, theoretical materi is illustrated by a wide variety of phys cally meaningful, practical problems. I addition, there is a large number figures and tables presenting design da for the solution of practical problem (Dunstan Graham and Duane McRue New York, Wiley, 1961. 482p., $9.75.)

*SPANNUNGSOPTIK.

A treatise on photoelasticity coverin both theoretical and practical aspec of both two-and-three-dimensional pr cedures. The beginning section provid the fundamentals of elasticity theor and optics. Later sections deal wit equipment, methods, models, stre lines, special applications, etc. A bibl ography of more than 1,000 reference arranged chronologically, covers fro the early 19th century to 1959. (Helm Wolf. Berlin, Springer-Verlag, 196 582p., DM 66.00.)

*STAHLBEHALTER FUR FLUSSIGE UND GASFORMIGE STOFFE.

A volume on steel tanks for liqui and gases. The design of the tanks a shown in drawings and photographs an reference is made to the difference be tween European and American tank Emphasis has been put on the trea ment of fuel oil, ball pressure, an chemical storage tanks. There is a cha ter on the various regulations for de sign, construction and operation of ste tanks, and the DIN and other standar specifications. The appendix includes in dications for regular supervision tanks, and a bibliography of mainly Ge man references. (Fritz Gross. Dusseldor Werner-Verlag, 1961. 152p., DM 29.00

*RARE EARTH RESEARCH.

Recent results in five selected areas rare earth research are presented, spe cifically, solution chemistry; oxide sy tems and their properties; and the stru ture, physical properties, and mechan cal and metallurgical properties metals, alloys, and intermetallics. Th material included is taken from Seminar held at Lake Arrowhead, Cal fornia, October, 1960, and has bee enlarged and brought up-to-date wit the addition of post-conference info mation and findings. (E. V. Klebe Galt, Brett-Macmillan, 1961. 313p $9.75.)

*SYMPOSIUM ON SHEAR AND TORSION TESTING.

The papers contained in this sym posium describe and evaluate new existing shear and torsion test methoc as used on various materials includin metals, welds, wood products, polymer and refractory materials. (Philadelphi American Society for Testing and M terials, 1961. 120p., $4.75. s.t.p. n 289.)

°IODIDE METALS AND METAL IODIDES.

The purpose of this reference book is to present to the chemist, engineer, or metallurgist, the information necessary to design and operate an iodide cell, the details of preparation and properties of metal iodides (including boron, germanium, and silicon iodides), and the ways in which these various iodide compounds can be used to prepare high-purity elements or alloys. A bibliography of 739 references is included. (R. F. Rolsten, New York, Wiley, 1961. 441p., $17.50.)

°INTRODUCTION TO FEEDBACK SYSTEMS.

The broad, basic concepts of linear feedback systems are presented. The content of this text is based on the pole-zero, root-locus approach, rather than the sinusoidal approach, and is designed to give the student a common background for all areas of application, including amplifiers, oscillators, and control systems. Of particular interest is an extended treatment of the linear oscillator, which is notable for its large number of text-integrated problems and examples. (L. D. Harris, New York, Wiley, 1961. 363p., $10.50.)

°PAPERS ON ROAD AND PAVING MATERIALS (BITUMINOUS)—1960.

Recent studies concerning the properties and performance of bituminous materials and mixtures are presented. They cover stress deformation characteristics of sand-bituminous mixtures, effect of compaction temperature on the properties of bituminous concrete, the influence of asphalt composition on its rheology, emulsified asphalt tests and specifications, and cationic asphalt emulsions. (Philadelphia, American Society for Testing and Materials, 1961. 91p., $3.50. stp no. 294.)

BASIC RADIO.

Another in the Rider "pictured-text" series, this volume presents the fundamentals of radio communications, and deals with the circuitry and techniques used for the transmission and reception of information via radio energy.

This volume is really six bound together as one, the first three volumes covering the basic components of electronic circuitry. The fourth volume shows how these components are assembled to form radio receivers, both AM and FM. Volume five covers semiconductors and transistors, and the theory and circuitry of transistor receivers, while the last volume deals with transmitters, antennas, and transmission lines. (Marvin Tepper. New York, Rider, 1961. 770p., $14.85. Each vol. available separately.)

(Continued on page 187)

Developments

(Continued from page 156)

A HIGH-PERVEANCE BEAM TUBE featuring low tube drop and high plate resistance for maximum circuit efficiency has been introduced by Raytheon Canada Limited. The tube's applications include series pass in regulated power supplies, a power switch to drive teletypwriters or similar dc wire lines, a screen grid clamper to protect Class C beams pentodes, a keyer for CW radio transmitters, for pulse output a flip-flop driver for computer logic matrix, a cathode follower in digital printers, a magnetic control tube and in magnetic drum write amplifiers, servo power amplifiers and passive switching amplifiers.

THE STEEL COMPANY of Canada announces a new Stelco 'Electrod' #7018, combining the excellent weld qualities of a low hydrogen electrode with the welding speed and ease of a high iron powder coating. The electrodes are designed to lessen the need for pre-heating or post-heating in a variety of problem applications, notably hardenable steels with high carbon and/or other alloy content. The low hydrogen rods increase the possibility of a sound joint with high impact resistance.

(Continued on page 165)

• Developments

(Continued from page 163)

PERMANENT MARKINGS on all grades and sizes of steel reinforcing bars are announced by the Steel Company of Canada Limited. The rolled-in markings are intended to provide a surer guide for contractors than tags or painted codes. All Stelco reinforcing bars will carry prominent markings to denote their origin of manufacture, and size.

A ROTOLINE DISTRIBUTOR for tricking filters, used for uniform filter bed dosing and high filter efficiency on both single-stage and two-stage bio-filtration systems, is now available from Link-Belt. The Rotoline is available for trickling filters from 20 to 200 feet in diameter, to handle flows up to 10,000 g.p.m. They are powered by hydraulic reaction developed when sewage flows through the nozzles and thus require no separate power source.

SPEED DRIVES, in a new range, statically controlled, and adjustable are available from the Dominion M. I. Limited, Montreal. Standard packaged units are available from 16 hp. to 50 hp. Optional additions may be made to the basic magnetic amplifier controlled servo loop to give control of current loading, speed regulation, the effects of line voltage fluctuations and to provide controlled tension or dynamic braking. Future additions may be made at any time as the drive requirements change.

BUDD INSTRUMENTS LIMITED, Don Mills, Ont., has introduced the BAM-3 Bridge Amplifier for shop and laboratory, strain gauge and transducer work to complement the BAM-1 Bridge Amplifier. The BAM-3 is for 4-arm strain gauge transducer work. The instrument has a minimum of controls and indicates the physical variable directly. Scope connection is provided for up to 10,000 cps operation. Battery or 110 volt operation.

A COMPLETE LINE of axial-flo, rotary compressors with capacities from 100 to 12,000 c.f.m., for use in industries employing compressed air for power, has been introduced by Canadian Ingersoll-Rand Co. Ltd. The C.I.R. Axi-Compressor is a special rotary machine embodying the principal of positive-displacement axial-flow compression. This method provides maximum economy for a wide range of pressure and capacity ratings which cannot be met efficiently with either reciprocating or centrifugal units.

A "BIG LOOK" TYPE 236 elapsed time meter for accurate timing of servicing and preventative maintenance is announced by Canadian General Electric. The meter is built in 2½- and 3½-inch models for panel mounting and in 2½-inch models for conduit-type case or portable stand applications. Sealed models for military applications are also available.

(Continued on page 176)

NATIONAL RESEARCH COUNCIL

Associate Committee

HEAT TRANSFER SYMPOSIUM

Afternoon, Friday, June 15th

Chairman:

D. L. MORDELL,

Dean of the Faculty of Engineering, McGill University

FIRST SESSION

SPECIAL LECTURE:

NOT OPEN FOR DISCUSSION

"Physics of Thermal Conduction Temperatures" *Dr. Preston Thomas,* Division of Applied Physics, National Research Board. 30 minutes

Summary Discussion of Following Papers: Rapporteur, *Professor W. A. Wolfe,* Dept. of Mechanical Engineering, University of British Columbia 20 minutes

(1) "The Temperature Regime and the Heated or Cooled Areas on the Ground Surface" *W. G. Brown,* Division of Building Research, N.R.C.
(2) "Calculation of Surface Temperature and Heat Flux from Sub-surface Temperature Measurement" *D. G. Stephenson and G. P. Mitalis,* Division of Building Research, N.R.C.
(3) "Research on Laminar Heat Transfer, Non-Newtonian Fluids" *Prof. Chi Tien,* Essex College, Assumption University.
(4) "Heat Transfer from Finned Surfaces" *Profs. J. W. Stachiewicz* and *A. R. McKay,* McGill University.
(5) "Contact Heat Transfer" *Prof. T. W. McDonald,* University of Saskatchewan.
(6) "Two-dimensional Steady State Analogue" *Prof. F. C. Hooper,* University of Toronto.
(7) "Departure from Nucleate Boiling" *Profs. D. G. Andrews and R. O. Pelham,* Dept. of Chemical Engineering, University of Toronto.

DISCUSSION FROM THE FLOOR 30 minutes

COFFEE BREAK

SECOND SESSION

SPECIAL LECTURE:

NOT OPEN FOR DISCUSSION 30 minute

"Limitations on Reactor Design Imposed by Heat Transfer Processes" *R. I. Hodges and/or another,* Atomic Energy of Canada Ltd. 30 minute

Summary Discussion of Following Papers: Rapporteur, *N. B. Hutcheon,* National Research Council. 20 minute

(1) "Energy Budget Approach to Heat Transfer of the Earth", *R. E. Munn and E. J. Truhler,* Meteorological Service, Dept. of Transport.
(2) "Laboratory and Field Studies of Properties of Radiation Instruments", *J. R. Latimer,* Meteorological Service, Dept. of Transport.
(3) "Temperature Distribution in Homogenous Slabs during Fire Test", *T. Z. Harmathy,* National Research Council.
(4) "Heat Transfer to Particles in High Temperature Surroundings", *Dr. W. H. Gauvin and another,* Pulp and Paper Research Institute, Montreal.
(5) "Organic Coolant Reactor Heat Transfer Problem", *Dr. J. T. Rogers,* Canadian General Electric Company.

DISCUSSION FROM THE FLOO

(Continued from page 165)

ATLAS COPCO. Canada Ltd., has introduced to the Canadian mining and construction industry the Jora Lift. Designed and developed in Sweden, the Jora Lift is an integral part of a new method of raise-driving which has proved practical and economical in service in Swedish mines. The advantages of this hoist method are, a greater rate of advance with less cost; and less risk of accidents than with older, more conventional raise-driving techniques.

"THE BEHAVIOUR OF SOILS UNDER DYNAMIC LOADINGS" will be the subject of a two week Special Summer Program at the Massachusetts Institute of Technology from August 27 to September 7, 1962. The program is designed to bring educators, researchers and practising engineers up to date on the most recent developments in Soil Dynamics as well as to provide a comprehensive review of the subject.

WESTOFLEX combines hardness, resilience and load bearing capacity in a new rubber type material said to be ideal for application in many mining locations. Since it is resistant to abrasion, it is applicable to the lining of chutes, bins and impellers and does not show any signs of brittleness in temperatures below -80 degrees Farenheit. This product is manufactured by Canadian Westinghouse.

ATLAS ASBESTOS has introduced a new asbestos-cement insulating and sheathing board known as Bipanel. The material used is a combination of a layer of impregnated fibreboard insulation laminated to a fire-resistant asbestos-cement sheet. It is flexible, weatherproof and is easily erected with hammer and saw.

FLYGT CANADA LIMITED is distributing a new full-color brochure describing the "Bibo-3" electric submersible pump, one of their new series of high capacity pumps. In discussing the features of the pump, the brochure points out the high capacity of up to 18,600 US gph, the maximum delivery head of 105 feet, an ability to efficiently handle water of 30% solid content and a compactness that enables a single man to easily handle it.

A MAGNETIC STIRRER, particularly suited to preparation of solutions and emulsions, stirring under vacuum and in closed vessels for flammable liquids and work in water and air baths, has been announced by Industrial Finishing Equipment Co., Hamilton. In this Stirrer, there is no physical contact between the stirring rod and the driving motor, thus there is no contamination from stuffing box lubricants. The synthetic covered stirring rod is immersed in the fluid and is put into rotation by a magnetic field. Rotation speed is adjustable by means of a knob from zero, and heat is controlled from 0-150 watts.

A MAJOR DEVELOPMENT in the concrete products industry of Ontario involves the merger of five major companies under the name of General Concrete Ltd. The participating companies are: Cooper Block Ltd., Toronto and Pickering; Gormley Block Co. Ltd., Gormley; Maple Block and Tile Ltd., Maple; Thorold Concrete Products Ltd., Thorold and Hamilton; York Block and Tile, North York. The most significant policy change will be in the field of specialization. Each division will concentrate on a selected number of products to achieve maximum productivity, improved quality, maximum product range and lower costs.

A NEW WATER level device for use in leveling and structure alignment has been announced by Soiltest Inc., a subsidiary of Cenco Instruments Corp. The water level is used in construction and industrial applications where conventional methods are not possible. Stainless steel anchor blocks are provided to be cast directly in the foundation walls on new construction or for surface mounting on existing structures. In this way, the measuring points can be permanently or semi-permanently installed for measurement against a fixed bench mark.

A COMPLETE LINE of ac general purpose motors, specially designed to accommodate the increasing emphasis on instrument miniaturization in aircraft, missile and industrial applications, has been introduced by the Kearfott Division, General Precision Inc. The basic unit of this series is an enclosed ac motor. Open-ventilated, finned and fan-cooled units are also available.

A SYSTEM FOR THE economical and efficient utilization of activated carbon and other adsorbents in the removal of organic materials from process liquor, has been introduced by Graver Water Conditioning Company, a Division of Products Tank Line of Canada Ltd. This process, called the Contraflux Adsorbtion System, is a moving-bed system which employs absorbents in a granular form, and provides a continuous counter-current contact of liquor and adsorbent with regular removal and regeneration of spent adsorbents. This System is applicable whenever separation and removal of specific organic substances is necessary.

TWO BULLETINS describing the new line of Econo Water Softeners, and the Econo Pressure Water Filters have been issued by the Industrial Division of Pumps and Softeners Limited of London, Ont.

A FLEXIBLE ROLLER CURVE unit for switching conveyorized items onto spur lines left, right or straight ahead, has been introduced by Rapistan Canada Limited. The Rapistan Three-way switch will divert materials from a common carrier 45-degrees left, right. Curve units are available for 12-inch, 18-inch or 24-inch conveyors.

(Continued on page 178)

(Continued from page 176)

A COMPLETE LINE of urethane resins, prepolymers, emulsions and elastomers for a wide variety of applications are now available from Wilmington Chemical Corporation. The Helithane and Helastic urethane materials can be used in the manufacture of sealants, extrusions, films, laminates, tubing, inks, circuitry, fibres, foams and compounds for caulking, molding, potting, encapsulating and insulating.

A FLEXIBLE URETHANE foam pipe insulation which can be quickly installed and provides thermal and moisture protection for liquid heating and cooling lines used in heating, refrigeration, plumbing, air-conditioning and industrial processing operations has been announced by United Foam Products. This preformed foam pipe, called Hewflex, is flexible enough to go easily around bends and over pipe joints without special fittings or tools. The foam sections are slit lengthwise down one side, allowing them to be quickly slipped over the pipe. Joints are sealed with Hewflex adhesive.

THE FOXBORO COMPANY, Montreal, has introduced a complete internal reflux computer control system packaged in a standard instrument case. The Computer, a pneumatic system, provides a continuous 3-15 p.s.i. output proportional to internal reflux flow. Refineries and chemical plants can, from this computed measurement, automatically control load disturbances which result when air fan coolers are operated under rapidly changing ambient conditions.

CANADIAN GENERAL ELECTRIC has announced four new matched diode assemblies made from the G. E. ultra high speed and controlled conductance P.E.P. silicon switching diodes. The two matched pairs assemblies, MP-1 and MP-2, and the new matched quads MQ-1 and MQ-2 are available in large quantities for mass production requirements.

SYNFLEX SELF-STORING AIR HOSE is the Nylon spiral air hose produced by Shaw Flexible Tubes Ltd., Toronto. Synflex retains its spiral form. It is abrasion-resistant and unaffected by oils, solvents, fuels, detergents and dilute acids. A 4-inch diameter coil only 9 inches long will extend 25 feet without fatigue to operator and retract without dragging or tangling.

A NEW LINE of circuit breakers, type QCC, are available from Canadian Westinghouse. The economically priced QCC breakers feature De-Ion arc quenchers, a quick-make, quick-break over centre toggle mechanism, and thermal magnetic trips. They are designed for service entrance use up to 240 volts A.C., and 10,000 Amps. maximum interrupting capacity.

A REVISED TEMPERATURE conversion chart especially keyed to four basic refractory metals, tungsten, tantalum, molybdenum and columbium, is available from Fansteel Metallurgical Corporation. The chart shows critical temperatures for these metals in Farenheit and Centigrade. It also gives formulae for converting either scale to the other. The chart lists 34 typical properties of the four metals.

THERM-O-SCOPE, a self-calibrat two-color pyrometer which operates measuring the same hot object at discrete wave lengths, eliminating emissivity effects from the tempera reading, has been introduced by M tron Inc., Pittsburg. Therm-o-sc achieves amazing speed and accurac recording changing ambient temp tures.

TO MEET THE growing need for e tronic circuits in space and military plications that will operate reliabl extremely high temperature and h radiation environments, General Elec has developed microminiature resis and capacitors that will operate u 600 degrees Centigrade, in severe ra tion environments. These tiny me ceramic components were designed use with TIMM (Thermionic Integra Micro Module) circuits, but are b made available in sample quantities development circuitry work.

FLOW RATE AS LOW AS 0.5 cc/ of water (equivalent) can now measured and transmitted with B Instrument Company's Model XI Low-Flow Rotameter. The XDDS Tr mitter utilizes a specially designed ferential transformer, the core of w is attached to the end of a mete float extension rod. As the float and falls in relation to flow-rate chan there is a corresponding increase or crease in the output of the second of the transformer. Adapting equipn is available to convert this output t signal for use with any recorder, troller, or remote indicator.

JNION CARBIDE, LINDE GASES DIVISION has introduced a new line of egulators for the delivery of ultra-pure ;ases. These stainless steel regulators re designed for use in a variety of pplications including crystal growing, ransistor brazing, switch and lamp filling, bright brazing and for handling of orrosive gases. They are ideal for use n chemical and pharmaceutical laboraories where outside contaminants affect rocess or research results.

. MODERN SPECIALLY DESIGNED actory is being built at Cowansville, Que., to house R.C.A. Victor's Electronic 'ube Assembly Plant. This is the Comany's sixth plant in Canada. Its contruction was necessitated by both the Research and the Communication Departments' need for more space. The ew plant, covering 10,750 square feet, ; being erected by Hill-Clark-Francis Quebec) Limited, and will be occupied n a long-term basis.

.N ONTARIO HYDRO HELICOPTER) be used for the complete airborne uilding of a 50-mile transmission line in Northern Ontario, performed pole-setng trials recently near Brampton. Six ,300 pound wood poles were airlifted, ne at a time and dropped into mahine-dug holes. This operation was a yout of methods to be used by pilots ho will fly the helicopter in the line uilding job this winter. The helicopter ill also be used to string conductors, irlift men and equipment. This will be e first major air construction of a ower line by Ontario Hydro.

NTERNATIONAL BUSINESS MAHINES has announced the developent of Hypertape, a high-performance, agnetic tape system incorporating sigificant engineering and technological lvances in tape handling, data encodg and tape movement. The new input/-utput system, for use with the IBM 74, 7080 and 7090 computers, is comosed of the IBM 7340 Hypertape drive nd the IBM 7640 Hypertape control. he principal engineering advances are new recording technique for greater liability and character density, an adanced single-capstan tape movement ystem and cartridge loading to eliminate l manual handling of magnetic tape.

NEW MOLECULARLY ORIENTED rylic sheet known as Tuffak has been mounced by Rohm & Haas Company. uffak combines the outdoor weathering operties of Plexiglas acrylic sheet with her specific characteristics which ake it particularly useful for a number applications. Tuffak is resistant to acking and crazing. It can be nailed punched without cracking if the oper technique is used. It can be used a glazing material since it is rigid, ansparent, lightweight and highly eather-resistant.

TERNATIONAL HARVESTER COMANY of Canada has announced the formation of a new, wholly-owned manufacturing subsidiary, Houghco Products Limited. This company will produce and sell the "Payloader" rubber-tired tractor-shovels, "Paydozer" pusher-dozer units, and "Paymover" towing tractors, which were developed by the Frank G. Hough Company, an affiliate of International Harvester. The new factory and offices will be built at Candiac, Que., with production staring at the end of 1962.

A 16-AMPERE 'Rock-Top' Trinistor controlled-rectifier has been made available in a high-reliability design by Canadian Westinghouse Company Limited. These new Trinistor devices, featuring hard soldered junctions and hermetically weld-sealed cases, are intended for industrial, military and consumer applications.

CARSEN INSTRUMENTS LIMITED Toronto is marketing a fibre glass tape measure with the trade name of ESLON. This tape is made from 30,000 individual lengths of fibre glass coated with tough plastic Polyvinyl Chloride, imparting a quality of extreme strength while retaining a soft flexibility similar to fabric. ELSON resists creasing, and remains accurate wet or dry. It has clear distinct graduations in either inches and eighths or tenths and half tenths.

ONTARIO HYDRO has announced the award of a contract valued at approximately $9 million to the Associated Electrical Industries of Canada Limited, for two 3,000,000-kilowatt steam turbogenerators. The units will be installed at Hydro's Lakeview Generating Station, now under construction west of Toronto.

A CONTRACT for the design and construction of a new crude and vacuum stilling unit and auxiliary facilities at the Port Credit refinery of Regent Refining (Canada) Limited, was awarded to the Fluor Corporation of Canada Limited. Regent is a subsidiary of Texaco. The project will increase the refinery's capacity from 26,000 to 35,000 barrels per day.

A NEW NAME in Canada, DeLaval Turbine Canada Limited, has assumed responsibilities for furnishing to Canadian industry, equipment designed by DeLaval Steam Turbine Company of Trenton, N.J. Headquarters are located in Toronto with a branch in Montreal.

VICKERS-SPERRY of Canada, Ltd., has announced the availability of piston-type accumulators for a wide range of industrial hydraulic applications. Shock-free operation and reduced maintenance are achieved through a new design combining a special seal assembly and a hollow floating aluminum piston. Vickers-Sperry accumulators are available in sizes ranging from 75 cu. in. to 2050 cu. in. total capacity and are designed for operating pressures to 3000 psi. EIC

Consulting Services

Library Notes *(Continued from page 155)*

YMPOSIUM ON ACOUSTICAL FATIGUE.

How to predict or measure the noise spectrum to which structure is exposed, how to determine the stresses and ration modes produced by that noise, how to predict fatigue life under such random loading, how to verify it prediction, and how to design for increased fatigue are the subject of the five papers included in this nposium. (Philadelphia, American Society for Testing and iterials, 1961. 65p., $2.50. stp no. 284.)

ROPERTIES OF CRYSTALLINE SOLIDS.

This volume contains papers from two symposia, "Re-nt Progress in Materials Sciences" and "Nature and igin of Strength of Materials", both held during the ty-third annual meeting ASTM, 1960, in Atlantic City, w Jersey. The emphasis is on the science of solids, blend- the disciplines of crystal physics, mechanics, chemistry, d metallurgy. (Philadelphia, American Society for Test- and Materials, 1961. 143 p., $4.00. stp no. 283.)

YMPOSIUM ON LOW-TEMPERATURE PROPERTIES OF HIGH-RENGTH AIRCRAFT AND MISSILE MATERIALS.

The papers contained in this symposium attempt to sent an overall picture of the present state of knowledge ncerning the cryogenic properties of high-strength ma-ials. Attention is focused on the mechanical properties high-strength sheet alloys at temperatures ranging down -423°F. Aluminum, magnesium, titanium, and stain-s steel alloys are studied. (Philadelphia, American Society Testing and Materials, 1961. 225p., $7.00. stp no. 287.)

ARGE-SIZE PERFECT DIFFUSORS, 2nd. ed.

A survey of the problems of light distribution for diffuse itters of both finite and infinite dimensions. Features the book include a set of 49 charts from which illumina-n values produced by diffuse light sources can be mputed directly, a set of coefficient-of-utilization tables be applied in computing modern installations for general hting, and a new method for computing the sky-tor in daylight engineering. In addition a rule of thumb given for bringing most of the problems relating to ge light sources within the scope of the simple inverse uare law and cosine law. (H. Ziji. Eindhoven, Phillips chnical Library, 1960. 196p., $4.50.)

PORT WRITERS' HANDBOOK.

This guide to procedures and techniques used in report iting covers preliminary planning, general organization, ural writing, use of supporting material, and selection l preparation of illustrations and tables. For those who st supervise production of reports there are sections development of format and design, and methods of nting and binding. A series of special notes warns report iters against unexpected pitfalls. (C. E. Van Hagan. glewood Cliffs, Prentice-Hall, 1961. 276p., $6.75.)

°UNDERSTANDING DIGITAL COMPUTERS.

Following an introduction which gives a broad explanation of what a computer is, this work discusses the basic logical elements, summarizes the circuits which can be used as building blocks, and describes the functional parts of the computer. A concluding chapter offers a detailed description of a specimen computer, and ties together the concepts and principles previously developed. The emphasis throughout is on principles rather than on hardware, and each principle is developed with illustrative examples and a minimum of complex mathematics. (Paul Siegel. New York, Wiley, 1961. 403p., $8.50.)

°STATISTICAL ANALYSIS AND OPTIMIZATION OF SYSTEMS.

The theory and methods underlying the analysis, synthesis, and optimization of systems in which statistical uncertainty is involved in the process dynamics are presented. Special features are an emphasis on nonstationary ensembles and time-varying linear systems, a simple interpretation of the adjoint method of statistical analysis for linear time-varying systems, a detailed consideration of the problem of producing minimum mean-squared error at any time with nonstationary statistics, and a thorough treatment of generalized criteria and restricted choices. All applications are illustrated with examples worked out in sufficient detail to display either the complete numerical results or the means by which they are obtained. (E. L. Peterson. New York, Wiley, 1961. 190p., $9.75.)

°SYMPOSIUM ON NUCLEAR METHODS FOR MEASURING SOIL DENSITY AND MOISTURE.

Newly developed nuclear methods for measuring the moisture and density of soil constitute the subject matter of this symposium. The papers presented describe the apparatus used in detail, present data obtained on specific projects, and evaluate the methods by comparing results with those obtained by the conventional sand-cone and oven drying methods. (Philadelphia, American Society for Testing and Materials, 1961. 105p., $4.00. stp no. 293.)

°HEAT, MASS AND MOMENTUM TRANSFER.

A parallel, unified treatment of the transfer of momentum, heat, and mass is presented. This parallel treatment emphasizes the similarity of the governing equations and at the same time indicates their areas of dissimilarity. Only two heat transfer mechanisms are suggested: conduction and radiation. Convection, free or forced, is identified as a bulk motion of fluid with the diffusion processes superimposed. Theoretical methods are developed in a series of problems logically arranged in the order of their complexity, and validated by recent experimental results. Important areas of application, such as boiling and condensation, and recent advances in areas such as high speed and high altitude flight, are considered in depth. (W. M. Rohsenow and H. Y. Choi. Englewood Cliffs, Prentice-Hall, 1961. 537p., $16.00.)

INDEX TO ADVERTISERS

APRIL 1962

PUBLICATION OFFICES: The Engineering Institute of Canada, 2050 Mansfield Street, Montreal 2, Quebec, Canada.

Association of Consulting Engineers of Canada Incorporated

The following firms have principals who are members of this Associatio engaged as professional engineers in engineering work independent c salaried employment or sales promotion.

The revenue derived from the sale of advertising space assists the Institute in publishing THE ENGINEERING JOURNAL on c regular monthly basis. Listed above are the names of the Companies and individuals whose advertisements appear in this issue

ADVERTISING OFFICES

QUEBEC: J. E. Donovan, Manager, Advertising Sales, 2050 Mansfield Street, Montreal, Phone: VIctor 2-8121
ONTARIO: L. G. Barnum, Manager, Advertising Sales, 160 Eglinton Ave. E., Suite 103, Toronto, Phone: 485-0789
WESTERN CANADA: W. George Turner, 501 - 191 Lombard Ave., Winnipeg, Man., WH 3-9123
EUROPE: H. A. Mackenzie, 4A Bloomsbury Square, London, W.C.1, England. Phone: HOlborn 3779
NEW ENGLAND STATES: R. G. Melendy, 17 Maugus Avenue, Wellesley Hills 81, Mass. Phone: CEdar 5-6503
CHICAGO: W. Reynold Ratz, 549 W. Randolph St., Chicago 4, Ill. Phone: ST-2-8811
NEW YORK: John H. Boyd, 17 East 45th Street, New York, Phone: MUrray Hill 7-0654
CALIFORNIA: Dunkle/Lehman Company, 740 South Western Ave., Los Angeles, Calif. Phone: DUnkirk 7-6149

President
B. G. BALLARD, HON. M.E.I.C.
Treasurer
E. JUBIEN, M.E.I.C.
General Secretary
GARNET T. PAGE, M.E.I.C.

EIC

THE
ENGINEERING JOURNAL

VOLUME 45 NUMBER 5 MAY 1962

LISHED MONTHLY BY THE ENGINEERING INSTITUTE OF CANADA, 2050 MANSFIELD ST., MONTREAL 2, QUE., CANADA • TEL. VI. 2-8121

Editor
GARNET T. PAGE, M.E.I.C.
Associate Editor
G. LA FONTAINE
Editorial Assistant
J. M. COUREY
Production Supervisor
M. V. KAY
Assistant Production Supervisor
D. N. SMITH
Manager of Advertising Sales
JOHN E. DONOVAN
Advertising Offices listed in Advertisers' Index
Circulation Supervisor
ROBERT G. HUNGATE

PUBLICATION COMMITTEE
Chairman: R. A. Phillips, M.E.I.C.
Members: B. O. Baker, M.E.I.C.
D. J. McDonald, M.E.I.C.
N. B. Hutcheon, M.E.I.C.
J. S. Walsh, M.E.I.C.
W. H. Gauvin, M.E.I.C.
P. Duchastel, M.E.I.C.
W. Bruce, M.E.I.C.
G. V. Meagher, M.E.I.C.
I. D. MacKenzie, M.E.I.C.
ex officio: D. L. Mordell

Printed in Toronto

rice $6.00 a year in Canada, British ossessions, United States and Mexico. 7.50 a year in Foreign Countries. Current sues, 75 cents a copy, back issues from 1.00 per copy up. To members, affiliates nd other bona fide engineers in Canada charge. Authorized as second class mail, the Post Office Department, Ottawa, d for payment of postage in cash.

MEMBERSHIP

CCAB BNA

Indexed in
The Engineering Index
The Applied Science
and Technology Index

CONTENTS

IN THIS ISSUE

IN THIS ISSUE

The continuous beam is encountered with sufficient frequency in structural design to warrant special consideration of its solution. The most familiar of elastic solutions is the moment distribution method. However, the advantages of the more rational inelastic design methods have been established with the Plastic Design Theory for steel structures. The uniformity of safety factor leads to a more economical use of materials and the simpler methods to savings in the design office. **C. Berwanger**, Assistant Professor, Dept. of Civil Engineering, University of Manitoba, presents in his paper, ***"The Limit Design of Reinforced Concrete Continuous Beams"***, the inelastic or Limit Design method. In this method continuous beams are made up of smaller segments or elements: Propped cantilevers (exterior spans) and fixed beams (interior spans). A complete solution of these continuous beam elements for required moment and rotation capacities is presented for both concentrated and uniform distributed loading. The solutions are presented in graphical form.

The application of a safety factor to the required rotation capacity is recommended where the fixity at the continuous support is not that of a fixed end.

Expressions for the moment and rotation capacities of reinforced concrete sections are presented. The use of equivalent loads replacing combinations of loading is demonstrated in a design example which also illustrates the proposed Limit Design method.

In his paper, ***"Civil Engineering Education"***, **S. D. Lash**, Head, Department of Civil Engineering, Queen's University, Kingston, states that engineering is a profession in which art and science are integral parts of a coherent discipline. The universities are training two groups of people, an elite, who will in due course become professional engineers and a larger group whose activities will often be of a sub-professional or non-professional character. Undergraduate training must therefore consist of general education plus a broad program of engineering studies, the latter consisting of applied science and technology. An engineering course is applied science and there is a danger of over-emphasizing the importance of basic science and mathematics and of under-emphasizing the humanities. The technological content of civil engineering courses must be varied and some selection must be made. Although practical experience is essential, in the training of a civil engineer, it is not necessary to limit this to summer vacations. University courses might well be shortened for those who wish to get their degree first and their practical experience later.

Graduate study is an increasingly important part of civil engineering education and at the Master's level, greater emphasis is now being placed upon course work than formerly. There is a danger that both Master's and Doctor's programs may be extended over excessive periods of time.

"Modern Techniques Solve Unusual Log Driving Problems" by **C. E. Davidge**, Assistant Hydraulic Model Engineer, at Hydro Electric Power Commission of Ontario, Toronto, and **D. M. Foulds**, M.E.I.C., Hydraulic Model Engineer at Ontario Hydro illustrates that techniques common to applied research work may be adapted to solve a complex log driving problem. An extension to the Cameron Falls Generating Station on the Nipigon River caused changes in the current in the forebay, which affected log driving operation of the Abitibi Power and Paper Company. Large quantities of wood collected on the racks of the powerhouse and logs were jamming between the guide booms some distance away from the entrance to the log chute. The extent of the affected area was determined by a float survey which also indicated the magnitude and direction of the surface currents. By moving the booms so as to parallel the direction of movement, a moderate improvement was achieved, however it was evident that some additional force was required to keep the logs in motion. Flow developers were considered to offer the most promising solution but this was checked before field testing by constructing a 1:24 scale model of the headpond and of each developer. The solution derived from the model tests was verified by the field trials where one full season of operation has been successfully completed.

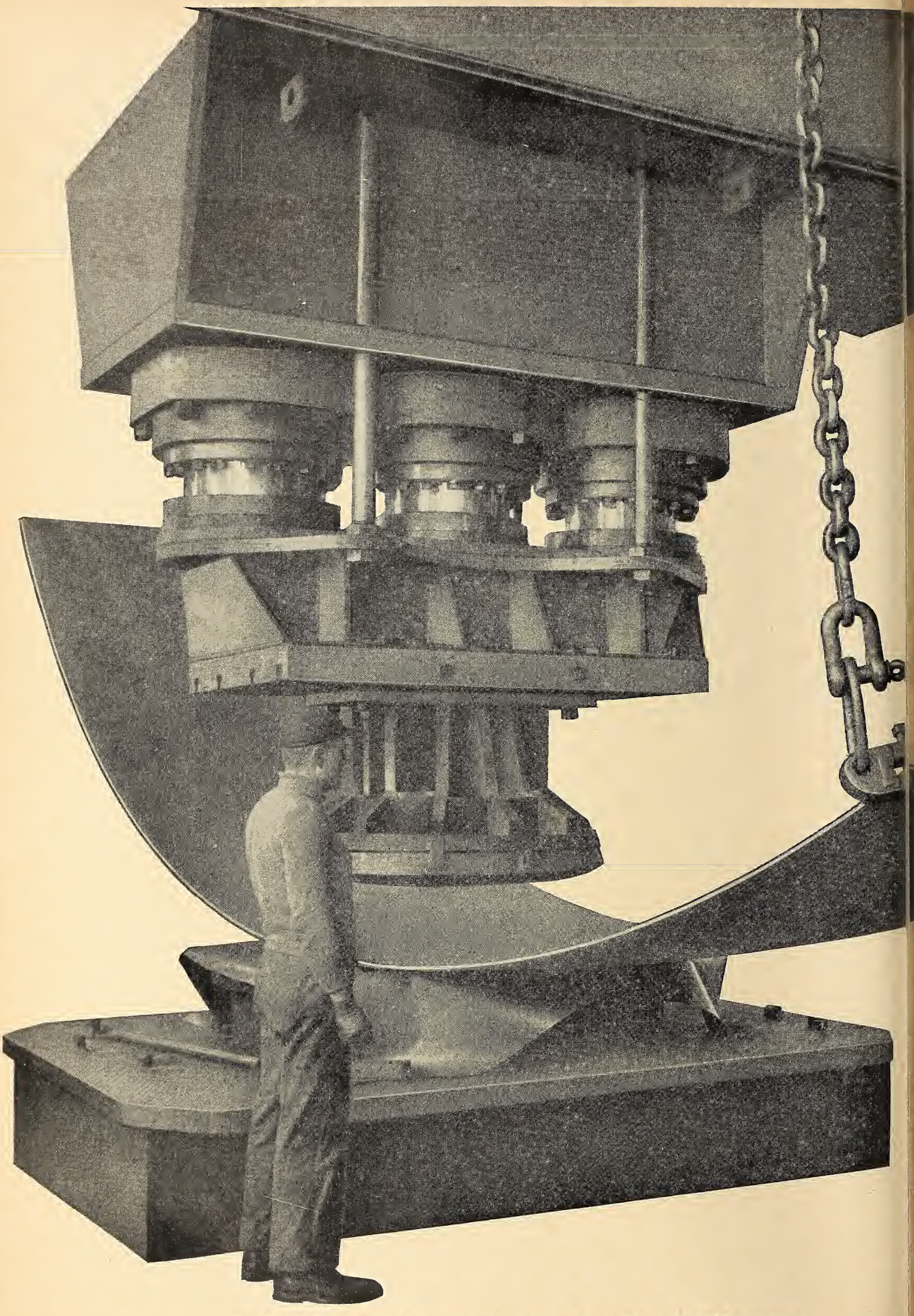
R. Salmon, A.M.E.I.C. Research Assistant, Queen's University, **W. B. Rice**, M.E.I.C., Associate Professor in Mechanical Engineering, Queen's University, and **L. T. Russell**, M.E.I.C., Naval Research Establishment, Defence Research Board of Canada, Dartmouth, N.S. describe in their paper, ***"Force Variation During the Formation of Continuous Segmented Chips in Metal Cutting,"*** the method of measuring the force variation and corelating it with the phase of segment formation in chips of 26S aluminum in which the segments were completely formed in .006 seconds. The results and the limitations of the method are presented. The research upon which this paper is based is supported, in part, by the Defence Research Board of Canada, under Grant DRB 9535-03.

During recent years, considerable improvement of design procedure and construction practice, based on intensified research and recognized engineering principles, has been achieved in the timber construction field. This development was not restriced to sawn timber construction only, but encompassed manufactured timber products, such as glued-laminated timber and structural building components made of plywood, foundation piling and pole frame construction, as well as wood preservation, timber fastenings and adhesives.

To make the results of this development work available to engineers and architects, it was necessary to establish new data covering materials and design procedure, in recognized specifications and codes. **J. W. Wynand**, Chief Engineer, Timber Preserves Ltd., in his paper ***"Current CSA Specifications on Engineering Design in Timber"***, presents the complete list of CSA Specifications dealing with structural wood and wood products, and gives a detailed discussion of the changes and reasons for changes of working stresses, grades, and design procedures.

COVER ILLUSTRATION

The 75th Anniversary Annual General Meeting of the Engineering Institute of Canada will be held June 12-15 in Montreal at the Queen Elizabeth Hotel, right foreground in the cover illustration. This picture taken from the Canadian Imperial Bank of Commerce Building, includes the cruciform-shaped Royal Bank of Canada Building at the left. (Photo courtesy Dominion Bridge Company Limited.)



Horton shop personnel pressing aluminum sphere plates on 1500 ton press.

ENGINEERING REVIEW 1961

General

Canada's economy in 1961 offered :olace for the optimist and fore-)odings for the pessimist. In just ıbout every area last year there was mprovement over the previous year. 3ut 1960, except for a relatively rosy :xport situation, was a difficult year.

Two important factors were the lecision to devalue the Canadian lollar, and the increasing interest :hown in the United States towards nodifying its tariff barriers.

By the beginning of the fourth ןuarter last year, though, the economy generally began to show signs of :trength and 1961 ended on a strong ıote.

Canada's Gross National Product esumed its sluggish rise, and by mid- /ear had surpassed the record towards he end of 1960.

Consumer spending on non-durables ınd in services was brisk, but in lurables the activity was static. In- lustrial production began early to ecover from the previous year's :lump. This helped to ease an ex- remely uncomfortable unemploy- nent situation. Business outlays :howed little strength and remained ar below the 1956-57 peak. Cor-)orate profits managed little more han to recover from the previous /ear's low.

The outlook for 1962 is for continued improvement. But the rate of advance may be slower than was anticipated six months ago. This improvement may satisfy the optimists. The pessimist may consider relatively high unemployment in an expanding economy, and the increasingly grim battle for a good share of the world's markets.

ALUMINUM

For the past few years the aluminum industry in Canada and in other countries has been operating at less than capacity. There are no indications that this situation will change in 1962. The demand for aluminum following the Second World War was great and many manufacturers expanded facilities to be in a position to handle the demand. A series of economic soft spots, such as the recession from which we still are recovering, has caused this demand to falter somewhat.

The industry generally has been using this slack time to improve facilities and methods so that production can go ahead with increased efficiency when the demand so warrants.

Canada consumes only about 15% of the aluminum produced here. The result is that the industry is extremely sensitive to international conditions. Included are the trend of many countries to nationalize industries, and the formation and increasing strength of common market groups.

Aluminum producers in Canada look to a somewhat firmer year in 1962, based mainly on better distribution and selling, and on increased use of aluminum in the building and construction fields.

AUTOMOTIVE

Along with many other major contributors to the economy, the automotive industry viewed 1961 as two halves. The first half was not particularly encouraging, but during the second six months sales increased rapidly. This situation is continuing in 1962.

Last year Canadians bought about 435,000 passenger automobiles. The indications are that 25,000 more will be sold in 1962. Truck sales are expected to maintain their level of recent years of about 75,000 units. A marked increase in construction projects would naturally upgrade this estimate.

CIVILIAN LABOUR FORCE

	non-institutional civilian population	total	agricultural	non-agricultural	total	agricultural	non-agricultural	paid workers: total	paid workers: non-agricultural	unemployed	persons not in the labour force	unemployed as percentage of labour force
	thousands of persons 14 years of age and over											
1960 J 16	11,678	*6,203*	608	5,595	5,656	593	5,063	4,607	4,522	547	5,475	8.8
F 20	11,699	*6,218*	583	5,635	5,619	568	5,051	4,599	4,519	599	5,481	9.6
M 19	11,712	*6,234*	605	5,629	5,625	588	5,037	4,583	4,507	609	5,478	9.8
A 23	11,735	*6,259*	651	5,608	5,707	641	5,066	4,639	4,543	552	5,476	8.8
M 21	11,759	*6,391*	682	5,709	5,972	675	5,297	4,867	4,755	419	5,368	6.6
J 18	11,780	*6,454*	690	5,764	6,139	682	5,457	4,996	4,883	315	5,326	4.9
J 23	11,806	*6,592*	828	5,764	6,262	819	5,443	5,011	4,869	330	5,214	5.0
A 20	11,825	*6,623*	827	5,796	6,271	820	5,451	5,035	4,874	352	5,202	5.3
S 17	11,843	*6,474*	767	5,707	6,147	757	5,390	4,961	4,822	327	5,369	5.1
O 15	11,862	*6,499*	713	5,786	6,131	695	5,436	4,988	4,870	368	5,363	5.7
N 12	11,878	*6,458*	674	5,784	6,029	649	5,380	4,924	4,821	429	5,420	6.6
D 10	11,893	*6,430*	635	5,795	5,902	610	5,292	4,830	4,741	528	5,463	8.2
1961 J 11	11,914	*6,396*	614	5,782	5,703	585	5,118	4,654	4,578	693	5,518	10.8
F 18	11,929	*6,363*	597	5,766	5,644	570	5,074	4,601	4,527	719	5,566	11.3
M 18	11,913	*6,353*	618	5,735	5,618	593	5,055	4,587	4,511	705	5,590	11.1
A 22	11,964	*6,440*	670	5,770	5,818	652	5,166	4,677	4,594	622	5,523	9.7
M 20	11,982	*6,542*	738	5,804	6,085	726	5,359	4,905	4,788	457	5,440	7.0
J 17	12,000	*6,592*	714	5,878	6,222	705	5,517	5,034	4,923	370	5,408	5.6
J 22	12,023	*6,743*	802	5,941	6,389	792	5,597	5,130	4,985	354	5,280	5.2
A 19	12,041	*6,704*	811	5,893	6,381	803	5,578	5,147	4,985	323	5,337	4.8
S 16	12,058	*6,543*	735	5,808	6,235	724	5,511	5,073	4,933	308	5,515	4.7
O 14	12,073	*6,538*	718	5,820	6,220	704	5,516	5,085	4,934	318	5,535	4.9
N 11	12,089	*6,504*	651	5,853	6,155	629	5,526	5,037	4,936	319	5,585	5.4
D 9	12,101	*6,495*	621	5,874	6,082	599	5,483	4,976	4,885	413	[illegible]	6.4

(DBS Table)

With the increasing demand there has been noted a decline in imports of European cars. Last year's imports of 107,000 units were 15% below those of the previous year.

This situation is explained, in part, by the entry into the market of smaller North American automobiles. In 1960 and 1961 their sales, respectively, were 57,000 and 76,000 units and the trend is expected to continue.

Prices held steady, and the industry hopes that this will continue at least until the end of the present model year.

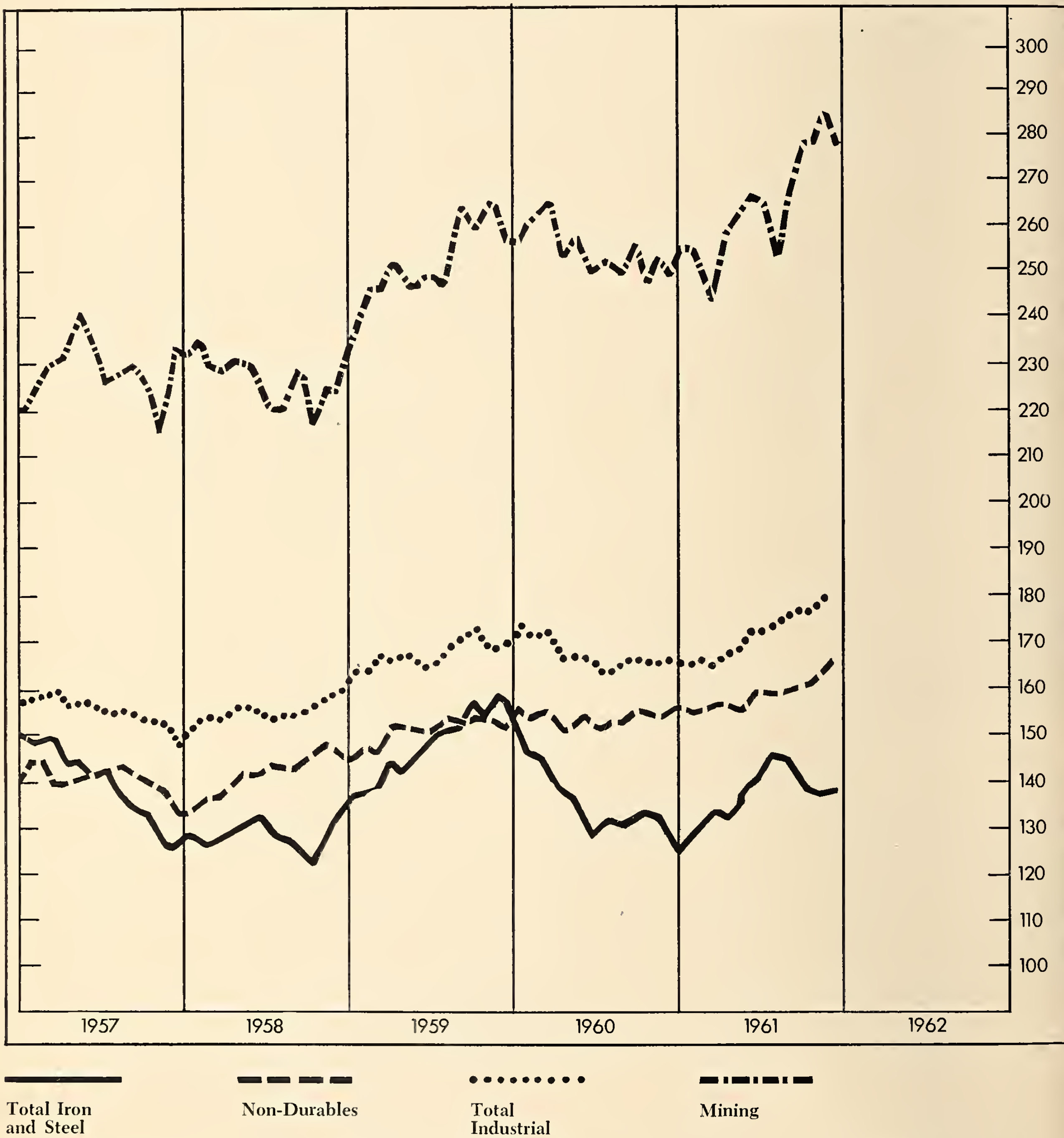
In Canada there now are registered 5,405,000 motor vehicles, including 4,225,000 passenger cars. This means that there are 10 passenger cars for every 43 Canadians.

CHEMICAL

Excess production capacity both in Canada and other nations of the world contributed to the most modest gain in the Canadian chemical industry since the end of the Second World War.

Among the consumer goods, there were few significant changes. Pharmaceutical preparations, medicines, paints and varnishes were essentially unchanged in demand, but the demand rose sharply for synthetic detergents. Increased output of chemical pulp and a high level of activity in the steel industry strengthened demand for some industrial chemicals. Sulphuric acid production was adversely affected by the continuing decline in the uranium industry.

Thus while domestic consumption increased only slightly, the import total increased, due largely to rising over-capacity in other countries. Countering this to a degree were the higher sales abroad of plastics and fertilizers.



The above graph reflecting trends in Industrial Production is based on figures compiled by the Dominion Bureau of Statistics.

COAL AND COKE PRODUCTION

		bituminous	*Sub-bituminous*	*lignite*	*Total*	*Nova Scotia*	*Alberta*	*British Columbia*	*imports*	*Exports*	*available for consumption*	*Coke production*
							Thousand tons					
60	J	655	222	248	*1,125*	448	271	70	186	43	1,268	354
	F	665	153	217	*1,034*	457	189	81	182	51	1,166	330
	M	702	135	217	*1,054*	486	177	81	200	62	1,192	380
	A	517	39	135	*691*	342	81	65	979	28	1,642	356
	M	544	30	102	*676*	334	91	71	1,515	74	2,116	344
	J	556	32	103	*691*	321	115	77	1,560	90	2,161	300
	J	603	27	90	*720*	375	106	71	1,069	79	1,710	311
	A	411	63	119	*593*	185	150	50	1,690	92	2,191	312
	S	728	143	168	*1,039*	458	249	76	1,553	101	2,490	297
	O	662	239	240	*1,141*	391	338	68	1,807	74	2,873	319
	N	701	278	282	*1,261*	439	370	74	1,281	93	2,448	289
	D	556	180	250	*986*	333	253	66	286	66	1,206	280
61	J	584	175	263	*1,022*	359	239	81	171	64	1,128	285
	F	553	130	222	*905*	352	178	78	172	66	1,011	270
	M	493	83	184	*760*	265	135	86	118	74	804	319
	A	545	52	146	*744*	346	101	77	682	97	1,330	329
	M	689	35	119	*843*	481	97	75	1,302	71	2,073	345
	J	609	23	114	*747*	399	89	78	1,331	97	1,981	343
	J	553	14	88	*655*	365	51	87	1,145	79	1,721	353
	A	328	42	91	*460*	145	94	57	1,634	71	2,023	341
	S	581	151	188	*920*	365	219	81	1,537	70	2,386	333
	O	660	230	241	*1,131*	427	291	93	1,783	111	2,803	335
	N	675	197	254	*1,127*	429	256	101	1,410			331
	D	557	229	300	*1,064*	368	278	71	585			316

(DBS Table)

Including chemicals used in the rocessing of such natural resources s pulp and paper and minerals, bout 34% of Canada's chemicals are xported. The lowering of the foreign xchange value of the Canadian ollar last year immediately improved ie competitive position abroad of anadian chemical producers.

Against this is the fact that about 5% of the chemicals consumed in anada are imported. In many cases ist year sweeping price cuts made by nited States and other foreign pro-ucers wiped out the benefits of the ower foreign exchange rate of the anadian dollar.

Two major factors are to be taken ito account when an analysis is ttempted of the chemical industry in anada this year and in future years. Vhile the industry is growing, its rowth rate has slowed, and in both 959 and 1960 this rate was below xpectations.

The two factors then are the gen-ral rate of economic recovery in both ie United States and Canada, and ie effects of increasingly competitive ctivity from foreign producers.

During 1961, very few new chemical products were manufactured for the first time. However, several projects for chemicals new to Canada are planned for this year. These include isocyanates, cyclohexane, lithium chloride and metal. All of these products now are imported. The emphasis will continue to be on new or expanded plants for such established products as caustic soda and chlorine, phosphates and urea.

COAL

During 1961 the production of coal in Canada reached its lowest point in 55 years. And while this was part of a long-time gloomy trend, the future prospects actually reveal some brightness.

Two main factors led to the decline of coal. These were the dieselization of the railroads, and the switch to oil or natural gas for residential heating.

The first caused a decrease in the production of bunker coal from about 12 million tons in 1951 to 700,000 tons last year. During the same period the consumption of household coal and coke fell from 13 million tons to 4.6 million.

It is expected, though, that bunker coal demand will stabilize itself at about 500,000 tons annually and that coal and coke demand probably will not be further affected by decreasing household demand. Another further decrease here may be picked up by the increased use of these fuels in large apartment blocks and similar projects.

Coal now is gaining ground in the iron and steel industry, and is holding its own in general industry. In addition, substantial gains are anticipated in the thermal electric field.

As has been noted elsewhere in this review, increasing interest is being shown in Canada in thermal generation. Ontario has exhausted its hydro resources situated at economical distances from the markets. Even the hydro-rich provinces of Quebec and British Columbia are giving increasing attention to thermal plants. This is expected to provide a long-term market for coal.

While the future does look brighter, the present remains somewhat gloomy. The upswing is expected to be long and gradual. In the meantime other marginal producers will be forced out of business.

PULPWOOD, WOOD PULP AND NEWSPRINT

		pulpwood production	*wood pulp production*			*wood pulp exports*	*newsprint production*	*newsprint shipments*			*stocks end of period*
			total	*mechanical*	*chemical*			*total*	*domestic*	*export*	
		thousand cords					*thousand tons*				
60	J	1,082	*889.8*	459.6	425.4	203.1	*527.4*	493.8	38.6	455.1	187.3
	F	871	*889.9*	462.7	422.4	187.9	*533.6*	494.8	40.6	454.2	226.0
	M	744	*965.6*	496.2	463.8	242.1	*575.0*	517.9	41.7	476.2	283.2
	A	521	*904.8*	469.1	430.7	197.7	*547.1*	589.0	38.9	550.1	241.3
	M	824	*932.9*	481.5	446.0	240.3	*563.1*	569.5	41.7	527.9	231.9
	J	1,695	*932.0*	483.8	442.8	198.8	*566.8*	593.2	43.0	550.2	208.0
	J	1,606	*908.5*	479.7	424.0	243.2	*555.9*	561.5	36.1	525.4	202.1
	A	1,722	*960.8*	493.4	461.6	260.5	*570.[illegible]*	551.8	37.1	514.7	220.8
	S	1,925	*932.6*	485.1	442.0	187.9	*570.6*	589.9	40.6	549.3	201.1
	O	2,001	*985.5*	505.9	474.4	242.3	*591.[illegible]*	588.2	42.8	545.4	204.6
	N	2,063	*999.8*	518.8	474.8	210.8	*604.[illegible]*	644.8	44.8	600.0	163.9
	D	1,308	*881.1*	459.7	416.1	186.6	*633.9*	558.1	41.2	516.8	139.8
61	J	992	*917.7*	466.1	446.5	223.6	*545.[illegible]*	509.2	38.6	470.6	176.0
	F	746	*891.1*	437.9	447.8	193.6	*511.9*	468.8	36.9	431.9	219.1
	M	507	*992.5*	487.8	498.7	238.6	*571.7*	528.1	45.0	483.1	262.7
	A	444	*931.5*	467.1	459.1	239.1	*549.1*	559.5	40.1	519.4	252.3
	M	721	*1,002.4*	508.7	487.8	249.1	*591.9*	583.1	44.1	539.0	261.2
	J	1,797	*978.1*	481.1	491.9	259.0	*558.8*	574.0	38.7	534.3	246.4
	J	1,333	*980.8*	476.1	449.0	226.9	*554.9*	552.7	36.1	516.6	248.7
	A	1,622	*1,018.0*	509.2	498.3	251.5	*585.[illegible]*	609.3	38.9	570.3	224.8
	S	1,552	*965.1*	483.7	475.8	226.4	*547.8*	555.3	43.1	512.2	217.[illegible]
	O	1,735	*1,035.5*	525.4	501.1	287.0	*596.5*	580.9	44.5	545.3	223.0
	N	1,798	*1,005.[illegible]*	510.8	480.2		*594.8*	618.6	44.3	574.3	199.1
	D	1,052	*900.7*	460.4	435.5		*548.[illegible]*	530.1	41.7	518.4	187.1

(DBS Table)

BUILDING PERMITS

		Canada	Newfoundland	Prince-Edward Island	Nova Scotia	New Brunswick	Quebec	Ontario	Manitoba	Saskatchewan	Alberta	British Columbia	residential	industrial	commercial	institutional and government
		thousand dollars														
1960	J	*77,092*	63	25	1,936	524	21,588	33,919	3,314	1,934	3,264	10,525	25,518	6,077	32,380	12 744
	F	*85,620*	107	108	295	269	19,555	34.045	4,878	1,285	11,087	13,991	38,563	10,354	17,155	19,402
	M	*134,977*	186	20	1,591	688	33,500	55,513	12,687	3,958	11,696	15,138	59,023	10,477	39,130	26,066
	A	*180,000*	2,179	160	1,639	2,161	37,111	82,265	9,679	5,307	17,335	22,164	85,987	12,965	41,665	38,710
	M	*217,642*	689	226	10,547	2,943	38,196	94,809	16,597	9,071	23,416	21,148	107,165	17,127	37,369	55,738
	J	*224,919*	1,304	280	2,319	2,362	55,069	100,425	11,964	10,386	21,884	18,926	107,960	29,072	39,118	48,418
	J	*179,273*	1,342	145	2,815	3,376	33,336	87,309	10,183	10,868	17,229	12,670	93,730	14,639	35,273	35,367
	A	*183,076*	1,563	114	5,307	3,763	37,466	84,234	13,221	6,341	15,371	15,696	84,575	16,196	23,302	48,731
	S	*205,316*	1,111	230	4,428	2,730	40,428	96,847	10,511	6,836	20,555	21,640	103,308	22,832	32,878	45,988
	O	*218,574*	582	236	2,850	1,080	61,368	92,552	9,469	7,109	24,550	18,778	95,913	18,035	58,960	45,278
	N	*194,355*	480	81	1,277	2,089	63,449	73,943	9,500	7,000	23,158	13,378	87,332	9,847	40,983	56,053
	D	*123,983*	175	733	1,064	578	23,610	69,958	3,047	5,140	9,576	10,102	55,425	16,600	24,536	27,341
1961	J	*94,989*	546	11	275	2,443	18,252	45,022	2,163	2,220	8,360	15,697	38,361	12,640	17,951	25,952
	F	*96,563*	190	35	3,117	370	19,326	45,607	4,057	2,348	10,252	11,261	47,605	12,273	19,447	17,161
	M	*177,393*	76	7	2,770	676	43,401	69,659	17,301	5,731	16,726	21,046	88,474	17,367	44,783	26,667
	A	*191,051*	449	751	2,383	1,713	45,525	86,001	6,771	8,059	25,315	14,084	122,657	10,966	32,429	24,843
	M	*248,772*	5,115	743	3,078	3,969	53,432	107,816	19,782	9,629	27,241	17,967	146,227	22,021	41,700	38,656
	J	*225,860*	2,013	879	7,223	3,881	48,478	94,012	9,082	9,873	25,820	24,599	126,640	18,559	39,880	40,670
	J	*227,888*	1,603	235	4,018	2,203	52,673	102,507	9,099	13,503	27,027	15,020	116,509	14,032	41,679	55,534
	A	*219,647*	1,468	910	3,880	2,256	54,829	96,328	9,209	8,508	22,986	19,273	114,708	21,121	44,499	39,204
	S	*200,303*	4,807	201	5,306	2,660	50,948	85,022	7,140	6,232	21,292	16,695	109,119	17,370	36,806	36,897
	O	*217,006*	1,995	316	3,918	4,831	56,027	86,101	7,591	12,423	21,178	22,626	113,900	19,357	44,967	38,637
	N	*191,540*	1,280	259	2,657	2,682	46,824	89,299	10,529	4,885	16,343	16,782	95,247	18,508	40,142	37,574
	D	*150,558*	248	3,356	5,597	2,197	29,489	80,680	2,535	4,963	9,585	11,908	55,148	13.770	33,062	48,544

(DBS Table)

CONSTRUCTION

The construction industry in Canada represents about 20% of the nation's gross product. This extremely important industry has had a volume of about \$7 billion a year since 1956. While there have been valleys and peaks, this total has been relatively constant, with a slight but discernible upward trend.

What is true for the whole also is true for the parts. Federal loans and municipal winter works programs provided the impetus to drive water and sewage work up more than 14% to a total of about \$250 million. Marine work was fairly steady although there is no foreseeable increase. On the other hand road construction work was steady in a potentially - expanding situation. Decreases in power and communications were offset by oil and gas projects.

These engineering works still represent relatively small slices of the entire construction industry volume. The bulk of the volume went to residential, industrial, business and institutional construction.

Of Canada's major centres, both Toronto and Montreal appear headed for another prosperous year in 1962. Both cities spurted last year with Toronto showing the larger increase. A start on Montreal's subway this year could reverse this situation.

ELECTRICAL

By the second quarter of 1961 the electrical industry began to shake off its previous year's lethargy. The recovery was, and is, gradual rather than spectacular. It is generally felt that this improvement will continue through 1962.

In the section of the industry concerned primarily with the engineering, production and sale of heavy electrical capital goods the recession was felt most severely. The primary reason was over-capacity in the plants of both utility and industrial customers. This over-capacity still exists in a good number of areas.

Among the encouraging factors last year was the increasing activity in paper, mining and steel. Offsetting this to a degree was the decline in pipeline construction.

With an eye to the future, apparatus manufacturers are entering new product fields to serve anticipated needs. Included would be the building and testing of air-blast circuit breakers which are vital components on EHV transmission system designed to move large blocks of power over large distances.

As has been noted elsewhere in this review electrical utilities are turning increasingly to thermal generation as available hydro resources are exhausted. This is true even in provinces such as Quebec and British Columbia which have large untapped hydro sources.

The steam turbo-generators required for this generation will be large units, and Canadian electrical manufacturers are investing heavily in upgrading facilities and manpower to compete with foreign manufacturers who have been in this field for many years.

Other needs which Canadian manufacturers are striving to fill include marine propulsion turbines and marine turbine generators. These needs were created largely by the St. Lawrence Seaway which can accommodate bulk vessels having a length of 730 feet, and a capacity of 25,000 tons.

The appliance segment of the industry fared better than the apparatus segment last year in spite of increasingly competitive conditions. Appliance and television manufacturers concentrated on improved products at lower prices, but in spite of this the consumer response was somewhat soft.

Japan's voluntary quota system on transistor radios was of some help to Canada's radio industry. On the other hand increased imports of tube models, on which there is no quota, worked its own hardships. The industry views with some apprehension the possibility of television receivers imported from Japan, and similar products from Europe, assuming similar proportions.

Looking ahead it is felt that the existing over-capacity in many heavy industries served by electrical manufacturers will be overcome only when the total economy moves forward in a dynamic fashion.

As the prospect for the total economy in 1962 is of moderate expansion, the electrical industry expects to move forward slowly.

NICKEL

Increased competition was the situation last year in the nickel industry, and it is expected that this competitive situation will become sharper in future years.

The basic cause is simple: capacity exceeds demand. This capacity is being steadily increased while there is no proportionate increase in demand.

Nickel producing capacity in 1961 increased about 15% from the previous year, and was about double the capacity of 1951.

During 1961 the United States, which consumes about 45% of the free world's nickel, started slowly but by year-end had gained considerable

PETROLEUM AND GAS

		Crude Petroleum		*Natural Gas*					*Sales of manufactured gas including liquified petroleum gas*		
						Sales					
		Imports	*Production*	*Production*	*Exports*	*Total*	*Residential*	*Industrial and commercial*	*Total*	*Residential*	*Industrial and commercial*
		Thousand Barrels		*million cu. ft.*							
960	J	9,510	18,319	50,479	8,474	36,344	16,082	20,246	195	121	74
	F	8,997	15,908	46,160	8,202	36,046	15,950	20,078	203	97	106
	M	11,124	17,387	49,041	8,545	37,153	15,968	21,168	204	79	125
	A	7,826	14,693	40,829	8,718	29,482	11,660	17,812	181	72	108
	M	9,692	16,682	38,940	8,653	24,344	7,481	16,851	178	63	115
	J	10,282	15,837	35,177	8,461	19,229	4,572	14,652	148	47	102
	J	11,493	16,150	33,857	8,325	16,384	2,997	13,384	121	46	74
	A	12,712	15,246	34,234	8,539	17,053	2,420	14,631	171	47	124
	S	11,734	15,654	36,256	8,131	18,230	3,060	15,166	168	60	108
	O	9,956	14,530	43,989	10,227	22,576	5,374	17,195	193	70	123
	N	11,459	15,013	50,736	12,068	29,870	9,935	19,922	212	71	141
	D	10,774	16,422	60,322	14,142	37,758	14,692	23,051	227	104	123
961	J	11,779	17,612	62,332	15,023	42,161	18,329	23,816	275	125	150
	F	10,317	16,479	56,457	14,284	40,293	17,799	22,477	252	102	150
	M	8,423	16,361	60,085	15,788	38,582	15,002	23,566	250	111	139
	A	11,830	16,845	53,607	13,970	34.131	12,416	21,705	233	103	130
	M	11,741	18,863	50,097	14,459	29,846	8,924	20,915	226	81	145
	J	10,607	17,893	44,000	13,187	22,223	4,673	17,547	216	81	135
	J	10,456	19,006	43,155	12,969	18,826	2,809	16,015	179	45	134
	A	12,053	19,644	45,606	12,085	20,352	2,547	17,803	199	41	158
	S	12,407	19,556	47,770	12,031	22,937	3,560	19,374	219	46	173
	O		18,174	54,398	12,361	29,440	7,056	22,377	244	58	186
	N				12,983	34,921	11,554	23,357	264	59	205
	D					43,352	17,361	25,977	271	96	175

(DBS Table)

strength. European consumption was below that of 1960, but still was quite vigorous. The United Kingdom and the Common Market countries consume about 35% of the free world's nickel. Japan consumes about 9%, Sweden about 4% and Canada about 2%.

The price of Canadian nickel was increased $ .4725 per pound in United States funds because of higher costs. Another development was the disposal, in co-operation with Canadian producers, of about 45 million pounds of nickel which was in excess of the United States government's strategic requirements. This was about 5 million pounds less than was disposed of the previous year.

It is felt in future years the demand for nickel will grow. So will the capacity to supply this demand. The result will be a hard competitive situation.

PETROLEUM

During 1961 Canada's petroleum industry continued firm. Natural gas, in particular, experienced a good year and expects that 1962 will be even better.

Development of gas resources, particularly in Alberta, and the construction of service facilities necessary to utilize these resources, was extremely vigorous.

In 1961 the main impetus for industry growth came from the preparation of production, processing and transportation facilities following approval of large export programs the previous year.

While the Trans-Canada Pipe Line's pipeline to export gas at Emerson, Man., was completed before the end of 1960, facilities related to the larger export scheme to take Alberta gas as far south as California had to be almost entirely completed last year.

Completed were seven plants for the processing of gas to remove such components as propane, butane and natural gasoline. In three cases sulphur from the field had to be removed. Of these seven plants, four were exceptionally large.

Two long stretches of 36 in. pipeline were placed. Alberta Gas Trunk Line Company Limited had to build a new gathering system in Alberta. The Alberta Natural Gas Company pipeline in British Columbia, to connect with the Alberta system, was completed in the Crowsnest Pass area to carry gas to the Idaho border.

Expenditures relating to the gas export project totalled more than $200 million with about $65 million for gas processing plants, about $100 million for the Alberta Gas trunk system, and about $40 million for the

ELECTRIC POWER AVAILABLE,[1] BY PROVINCES

		Canada	*Nfld.*	*P.E.I.*	*N.S.*	*N.B.*	*Que.*	*Ont.*	*Man.*	*Sask.*	*Alta.*	*B.C.*
		million kilowatt hours										
959		*8,315*	110	6	135	128	3,212	2,949	357	125	258	1,022
960		*9,076*	116	7	143	139	3,658	3,082	379	139	288	1,111
959	N	*8,906*	110	7	143	138	3,413	3,162	397	135	288	1,101
	D	*9,332*	120	7	153	143	3,697	3,281	413	144	300	1,146
960	J	*9,608*	123	7	152	143	3,734	3,281	429	152	311	1,163
	F	*9,110*	120	6	142	135	3,640	3,132	400	140	290	1,093
	M	*9,725*	127	7	153	143	3,901	3,326	422	146	305	1,180
	A	*8,987*	111	6	140	131	3,682	3,041	377	127	267	1,081
	M	*8,858*	116	6	136	139	3,550	3,059	352	127	267	1,094
	J	*8,599*	111	6	132	140	3,185	2,936	337	122	264	1,053
	J	*8,422*	111	6	129	129	3,474	2,816	319	122	259	1,042
	A	*8,708*	115	6	137	133	3,603	2,903	335	133	270	1,058
	S	*8,824*	112	6	136	131	3,580	2,938	418	133	278	1,077
	O	*9,206*	118	7	146	137	3,767	3,077	361	140	291	1,116
	N	*9,276*	116	7	153	155	3,686	3,145	367	154	311	1,165
	D	*9,680*	112	8	158	154	3,793	3,326	428	172	337	1,183
961	J	*9,808*	117	8	157	152	3,809	3,367	452	172	331	1,224
	F	*8,891*	104	7	150	129	3,520	3,022	382	148	303	1,111
	M	*9,668*	113	7	154	142	3,861	3,267	401	155	319	1,232
	A	*9,087*	107	7	144	139	3,646	3,097	374	141	289	1,128
	M	*9,297*	114	7	145	145	3,712	3,166	397	144	297	[illegible]
	J	*8,580*	112	6	138	143	3,354	3,053	361	137	292	[illegible]
	J	*8,313*	108	7	134	146	3,394	2,946	350	142	279	[illegible]
	A	*8,615*	124	7	137	116	3,514	3,030	370	149	297	[illegible]
	S	*8,772*	104	7	145	152	3,477	3,104	376	150	308	[illegible]
	O	*9,643*	113	8	156	164	3,714	3,282	403	155	332	[illegible]
	N	*9,713*	119	9	156	159	3,717	3,371	419	165	348	[illegible]
	D	*10,139*	121	9	159	169	3,846	3,516	473	195	389	1,243

[1]Total net generation less net exports

DBS Table

Alberta Natural Gas pipeline.

The oil producers responded to the federal government's stated production goals with a 1961 total of 234 million barrels of crude oil and natural gas liquids. Alberta accounted for 168 million barrels of the total output.

The increase in oil production over 1960 was 30 million barrels.

This additional production was absorbed in two main areas. The United States increased its exports from 42 million barrels in 1960 to 66 million barrels last year. Ontario's consumption increased 12 million barrels to 83 million.

The production of natural gas also reached a new high of more than 660 billion cubic feet, or about 150 billion cubic feet more than in 1960. Slightly more than half the gain came from increased domestic use and the remainder from increased imports by the United States.

POWER

After 16 years of major hydro development in Canada, thermal development once again came to the fore. For the first time since 1945 the capacity of newly-installed thermal electric power production facilities in Canada exceeded the capacity of new hydro generating plants.

In 1961 the addition to Canada's hydro capacity totalled 294,650 hp. —only about one-quarter of the new power made available. Additions to existing thermal capacity totalled 667,725 kw.

In the nuclear field, work progressed on two well-publicized nuclear electric power generating stations. At year's end the 20 Mw. Nuclear Power Demonstration station at Rolpton, Ont., was nearly complete.

Work continued at the Canadian Deuterium Uranium (CANDU) station at Douglas Point, near Kincardine, Ont. The NPD plant was built as a precursor of larger, more economical nuclear stations, such as the 200 Mw. CANDU.

Both of these Atomic Energy of Canada, Limited plants will be tied into the Hydro Electric Power Commission of Ontario network.

NPD and CANDU are fuelled with natural uranium and cooled and moderated by heavy water. Much more than plants which simply produce power, they represent the sustained growth of Canadian engineering and scientific competence in the design, construction and operation of heavy water, natural uranium power reactors.

The operation of CANDU is expected to demonstrate that this reactor is economically competitive, and to open the world market for nuclear power to Canadian industry.

Of greater immediate assistance, however, will be conventional hydro and thermal power. The Canadian trend to thermal plants is expected to continue during 1962.

Advantages of combining both thermal and hydro generating facilities are receiving increased recognition, even in such provinces as Quebec and British Columbia, where there are still large hydro-electric sites which can be developed economically.

Current construction will put an additional 900,000 kw. of thermal power into service during 1962. In the planning stage are projects which should add an additional 2,500,000 kw. in the foreseeable future.

During 1962 an additional 416,000 hp. of hydro capacity will be brought into service across Canada and projects in the planning stage indicate a reasonably early addition of 8,100,000 hp. Of this, a major portion—about 5,100,000 hp.—will be achieved through the development of Quebec's Manicouagan and Outardes rivers.

RAILWAYS

Both Canada's major railways continued their improvement programs during 1961 While these programs are designed to increase efficiency and lower costs, not all the benefits were realized last year. As with any major segment of the economy, the railway's prosperity is tied directly to the prosperity of the nation.

The Canadian National Railways and the Canadian Pacific Railway both extended their piggyback services. The CPR, for the first time, handled trailers of private industry, and also completed ground work for interchange of piggyback traffic with United States railroads.

The CNR added new freight rolling stock, extended its electronic signalling network, continued its main line upgrading and introduced incentive plans for both shippers and passengers. Its Telex network again was expanded.

New yards and yards facilities were added by the CPR. Centralized control was extended and sales offices were integrated. The Telex network was extended to 66 from 37 stations.

"While every effort is being made to improve the position of the company through provision of improved equipment, new services, and modern merchandising methods," CPR President N. R. Crump wrote in the Montreal Gazette, "it is unfortunate that depressed statutory freight rates impose a heavy and unwarranted burden. Canadian Pacific, with its freight rates frozen by government decree and faced with fantastic new wage demands from the non-operating unions, calls for fresh, new thinking along the whole broad front of government-labor relations."

TOTAL ELECTRIC POWER

		net generation					*net exports*	*available*		
		hydraulic	*thermal*	*total*	*utilities*	*industries*		*total*	*primary*	*secondary*
		million kilowatt hours								
1960	J	9,191	698	*9,889*	7,828	2,061	381	9,508	8,814	694
	F	8,790	654	*9,444*	7,401	2,043	334	9,110	8,410	700
	M	9,320	752	*10,071*	7,821	2,250	346	9,725	8,961	765
	A	8,811	600	*9,411*	7,296	2,115	424	8,987	8,287	700
	M	8,765	603	*9,369*	7,392	1,977	510	8,858	8,275	584
	J	8,557	578	*9,135*	7,165	1,970	536	8,599	8,027	572
	J	8,477	579	*9,057*	7,047	2,009	635	8,422	7,882	540
	A	8,643	683	*9,326*	7,212	2,115	618	8,708	8,172	536
	S	8,521	735	*9,256*	7,165	2,091	432	8,824	8,297	527
	O	8,784	794	*9,578*	7,423	2,154	371	9,206	8,636	571
	N	8,812	778	*9,591*	7,475	2,116	316	9,275	8,751	524
	D	9,096	814	*9,910*	7,758	2,152	224	9,686	9,138	548
1961	J	9,096	893	*9,989*	7,810	2,179	181	9,808	9,243	565
	F	8,156	861	*9,018*	7,002	2,016	126	8,891	8,430	461
	M	9,030	837	*9,867*	7,599	2,269	199	9,668	9,071	597
	A	8,732	687	*9,419*	7,318	2,101	332	9,087	8,522	565
	M	8,988	701	*9,689*	7,604	2,085	393	9,297	8,673	624
	J	8,276	630	*8,906*	7,021	1,885	320	8,586	8,228	358
	J	7,978	665	*8,643*	6,941	1,701	330	8,313	7,888	425
	A	8,066	767	*8,833*	7,077	1,755	217	8,615	8,214	401
	S	8,169	824	*8,993*	7,203	1,790	221	8,772	8,341	431
	O	8,882	855	*9,737*	7,645	2,092	194	9,543	9,058	485
	N	8,949	897	*9,846*	7,737	2,110	133	9,713	9,233	479
	D	9,349	929	*10,279*	8,102	2,176	139	10,139	9,607	533

(DBS Table)

RESEARCH

Research can not be gauged on a year-to-year basis. Other sections in this summary report have compared 1961 with the previous year, and have attempted to project into 1962 and the future.

Research is the basis of progress. It is that obvious, and that necessary.

There are two broad research areas —in industry and in university. While they may be approached differently—applied or pure research—they both fill fundamental needs.

Canadian industry is hampered by a domestic market that ordinarily permits less-than-optimum production. Research is necessary to drive down the unit costs. When this is done, the product most often becomes highly competitive in world markets.

In universities the situation is clear cut. A crisis exists in higher education and this crisis will worsen unless universities are given the money to fulfill their functions.

The most commonly mentioned financial amount required by university sciences is $10 million a year for at least the next five years. This money is needed for buildings, facilities and scholarships or fellowships.

E. W. R. Steacie, President of the National Research Council, summed the situation in a recent statement:

"The financial stability of our universities in this period of unprecedented growth is vital both to our domestic needs and to our responsibilities in the world at large. The opportunities we now have to control and direct our own destiny must not be allowed to slip away."

SHIPBUILDING

After a number of increasingly stormy years, Canada's shipbuilding industry appears headed for better weather.

The big factor was the decision made last May by the Federal Government to subsidize shipbuilding in Canada. The result will be that Canadian shipyards will be able to produce vessels at about the same cost as their British counterparts.

The government also decided to reserve the coasting trade on the St. Lawrence and the Great Lakes to Canadian ships.

Some results may have been noticeable late in 1961. In November, employment in the industry had increased to 10,500, up about 2,000 in 10 months.

During 1961 eight ships were completed for the federal government—three passenger-cargo ships and two pilot boats for the Department of Transport, a hopper suction dredge, a tug and a dump scow for the Department of Public Works.

Three upper lake type bulk carriers, the "J.N. McWatters", "Whitefish Bay" and "Canadoc", three package freighters, the "Fort Chambly", "French River" and "English River", one tanker, the "J. Edouard Simard", 16 barges and one tug were delivered to domestic commercial shipowners to serve specialized trades in water transportation.

Two small vessels, a diving tender and an oil disposal and cleaning barge, and five barges for the Royal Canadian Navy were completed.

No ships were built for export.

STEEL

While most of Canada's economy made a halting recovery last year, the steel industry was enjoying a record year. Ingot production of about 6.3 million tons represented an increase of about 10% from the previous year. It compares with the previous high, set in 1959, of 5,921,800 tons.

Exports last year were smaller in tonnage but higher in profit. The percentage of exports dropped to 12.5% from about 19%.

This points up the great dependency of the steel industry upon secondary industries for growth and prosperity.

Canada's steel makers have earned respect in world markets for their quality and imagination. During 1961, for example, oil and natural gas were used for the first time as fuel supplements in blast furnace operation. With this is the growing use of pellets, self-fluxing sinter and other forms of beneficiated ore.

Lighter and stronger steels for construction were introduced last year, along with higher strength reinforcing rods for reinforced concrete, and light-weight tin plate for can making. These new steels are in direct competition both with imports and with substitute materials.

Also being produced now are wide-flange structural members, and plate much wider than was possible to manufacture in Canada a few years ago. Canada now is self-sufficient in tinplate and in galvanized sheets.

CHEMICAL ENGINEERING PAPERS ARE INVITED FOR JOINT CIC-EIC CONFERENCE at Sarnia, Ontario, October 22nd to 24th, 1962

The Chemical Engineering Division of the E.I.C. Committee on Technical Operations will join with the Chemical Engineering Division of the Chemical Institute of Canada in a Joint Divisional Technical Conference to be held at Sarnia, October 22nd to 24th. E.I.C. members in the field of Chemical Engineering are invited to submit papers. In this connection, all Branch Chairmen and Chairmen of Papers Committees are urged to support the EIC by using their efforts to obtain suitable papers. All suggestions for papers and offers of papers should be submitted as soon as possible to —

The General Secretary
2050 Mansfield Street, Montreal.

LIMIT DESIGN OF REINFORCED CONCRETE CONTINUOUS BEAMS

C. Berwanger, M.E.I.C.,
Assistant Professor, Dept. of Civil Engineering, University of Manitoba

THE ADVANTAGES of the more rational inelastic design methods have been established with the Plastic Design Theory for steel structures. The uniformity of safety factor leads to a more economical use of materials and the simpler design methods to savings in office time.

In general, the inelastic theory of structures may be applied to any structural material with adequate moment-ductility or moment-curvature characteristics. Sufficient ductility is required at the critical sections in order that a redistribution of moments results in the ductile collapse of the structure. Thus a structure has definite moment and rotation requirements at its critical sections. There must be sufficient rotation capacity at the sections first reaching ultimate moment capacity in order that the remaining sections may reach ultimate capacity. In the case of reinforced concrete, and other materials of limited ductility, the required rotation capacities at the critical sections must be determined.

This paper presents an inelastic or Limit Design method in which continuous beams are considered made up of smaller beam segments or elements: propped cantilevers (exterior spans) and fixed beams (interior spans). The complete solution of these continuous beam elements is presented for required moment and rotation capacities for both concentrated and uniform distributed loading. The solutions are presented in graphical form to facilitate design.

The variation of fixity at the continuous supports is discussed and the application of a safety factor to the required rotation is recommended. Design expressions for the moment and rotation capacities of reinforced concrete sections are included. The design problem illustrates the proposed Limit Design method as well as the use of equivalent loads to replace combinations of loading.

Some additional factors that would require consideration in design are adequate shear strength, adequate bonding and anchorage of steel reinforcement, the increased deflections due to a reduction of beam flexural rigidity and increased slenderness of members, as well as any factor that might produce the premature failure of the structure. A proper design should insure that the ductile collapse of the structure, at ultimate load, can be realized.

EXTERIOR SPANS

Propped Cantilever with Concentrated Load

Elastic Behaviour and Modes of Failure: Consider a propped cantilever of span *L*, as shown in Fig. 1, with a

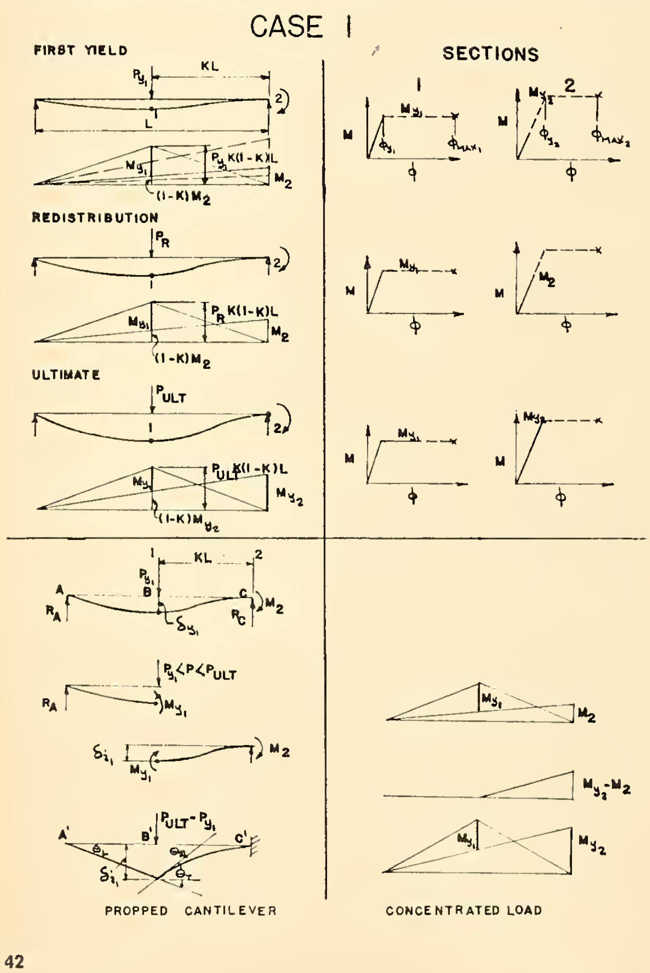
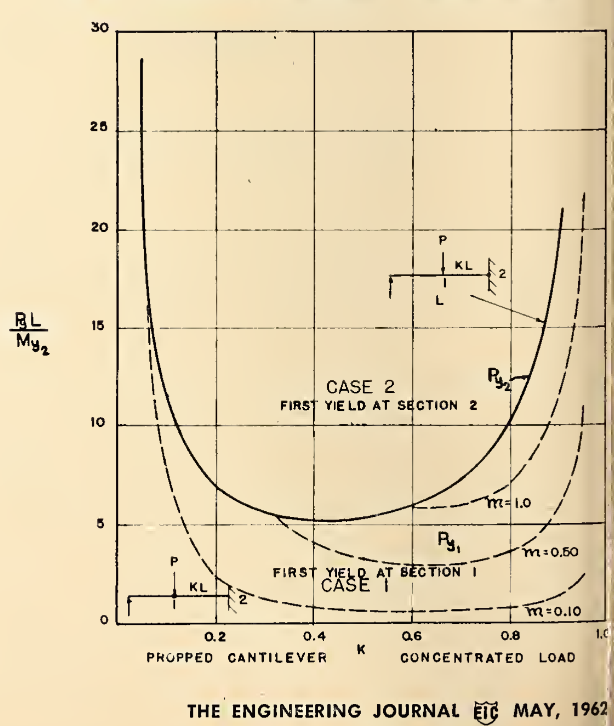


Fig. 1. (left) Load-Moment Relationship (Ideal)

Fig. 2. (below) First yield load vs position of load



single concentrated load, P, applied at a point that is a variable distance KL from the fixed end or continuous support. The moment diagram shown in Fig. 1 is completely described by M_1 and M_2, the moments at the critical sections 1 and 2. For elastic behaviour, $0 < M \leq M_y$;

$$M_1 = \frac{PLK^2(1-K)(3-K)}{2} \qquad (1)$$

$$M_2 = \frac{PLK(1-K)(2-K)}{2} \qquad (2)$$

and:

$$\frac{M_1}{M_2} = \frac{K(3-K)}{(2-K)} \qquad (3)$$

Let

$$m = \frac{M_{y_1}}{M_{y_2}} \qquad (4)$$

the ratio of the yield moment capacities of the two critical sections, and consider only $m \leq 1.0$.

The yield moment capacity may first be reached at section 1, under the load, or it may first occur at section 2, at the continuous support, or simultaneously at both sections. These alternate modes of failure have been termed "Case 1", "Case 2" and "Mechanism" respectively.

The ratio of loads for first yield at section 1, P_{y_1}, and at section 2, P_{y_2}, is

$$\frac{P_{y_1}}{P_{y_2}} = \frac{m(2-K)}{K(3-K)} \qquad (5)$$

For first yield at section 1, with section 2 still elastic,

$$\frac{m(2-K)}{K(3-K)} < 1.0$$

When

$$\frac{m(2-K)}{K(3-K)} > 1.0$$

first yield occurs at section 2 and for

$$\frac{m(2-K)}{K(3-K)} = 1.0$$

yield occurs simultaneously at 1 and 2, and a collapse mechanism forms immediately.

Figs. 2 and 3 are graphical presentations of these elastic equations. They permit the rapid determination of the mode of failure, Case 1, Case 2, or Mechanism, for all values taken by the parameters K and m.

Inelastic Behaviour — Moments and Loads: The behaviour after first yield has occurred is largely dependent upon the assumptions made regarding the moment-curvature relationship of the critical sections. To develop the simplest possible expressions for design purposes the ideal elastic-plastic moment-curvature relationship, shown in Fig. 4, is assumed. Analyses based on the non-ideal or elastic-strain hardening moment-curvature relationship have been developed by the writer in previous work.[1,2]

The behaviour after first yield may be seen by considering Case 1. At first yield the load is P_{y_1}. The moment at section 1 is M_{y_1} and that at section 2 is $M_2 < M_{y_2}$ (See Fig. 1). As the load is increased into the range $P_{y_1} < P_R < P_{ULT}$ inelastic rotation occurs at section 1 (under constant moment M_{y_1}), with M_2 increasing towards M_{y_2}. In order that the collapse mechanism can form it is essential that the inelastic rotation capacity of section 1 be adequate to permit M_2 to reach M_{y_2}. When section 2 yields, $P = P_{ULT}$, the ultimate load capacity is reached and further deformation occurs under constant load until one of the "hinges" is destroyed, as by crushing of the concrete.

The behaviour of Case 2 failure is similar to that of Case 1. In the case termed Mechanism both critical sections yield simultaneously and no inelastic deformation is required, with $P_y = P_{ULT}$.

From considerations of static equilibrium the ultimate load for ideal inelastic behaviour, is:

$$P_{ULT}KL(1-K) = M_{y_1} + (1-K)M_{y_2} \qquad (6)$$

combined with Eqs. (1) and (4) to give the load ratio

$$\frac{P_{y_1}}{P_{ULT}} = \frac{2m}{K(3-K)(m+1-K)} \qquad (7)$$

for a Case 1 failure. Similarly the load ratio for a Case 2 failure, is

$$\frac{P_{y_2}}{P_{ULT}} = \frac{2}{(2-K)(m+1-K)} \qquad (8)$$

Inelastic Behaviour—Curvatures and Rotations: Case 1—The curvature due to moment at first yield is

$$\varphi_{y_1} = \frac{M_{y_1}}{EI} \qquad (9)$$

in which EI is the flexural rigidity of the section.

After first yield any additional load must be "carried" by the right hand part of the beam, BC (Fig. 1). AB undergoes rigid body movement with constant moment, M_{y_1}, at its right end. The plastic hinge separates the two elastic parts of the beam, and is spread over some finite distance called the hinge length, H_L.

From the free body diagram of Fig. 1, it can be seen that BC is now in effect a cantilever with the differential load $(P_{ULT} - P_{y_1})$ at its free end. The increase in curvature at the hinge, over that at first yield, is the total angle of inelastic rotation or angle of discontinuity between the elastic portions

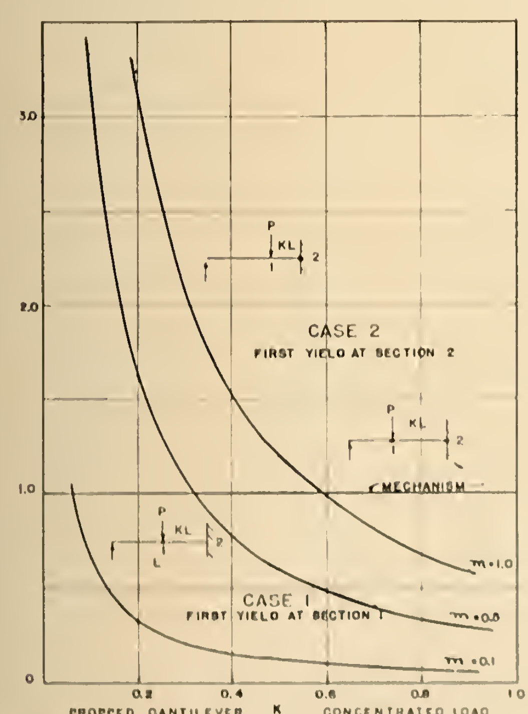
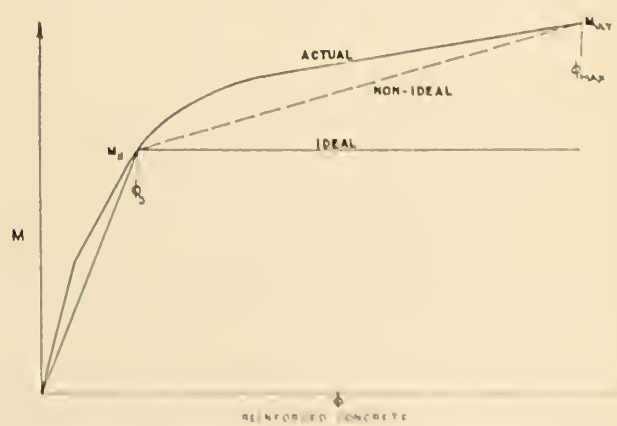


Fig. 3. (left) First yield load ratio vs load position

Fig. 4. (below) Moment-curvature relationship



of the beam taken over the hinge length.

This increment of curvature at section 1, is

$$\phi_{i_1} = \frac{\theta_T}{H_L} = \frac{\theta_L + \theta_R}{H_L} \qquad (10)$$

in which θ_T is the total rotation at the hinge, and θ_L and θ_R are the respective angles of rotation of the left and right portions of the beam.

Consider only the increment of load $(P_{\text{ULT}} - P_{y_1})$ acting on the cantilever $B'C'$, and taking a new datum, then the angle between the tangent to the cantilever at B' and the new reference, is

$$\theta_R = \frac{(P_{\text{ULT}} - P_{y_1})(KL)^2}{2EI} \qquad (11)$$

The deflection at the free end of the cantilever, is

$$\delta_{i_1} = \frac{(P_{\text{ULT}} - P_{y_1})(KL)^3}{3EI} \qquad (12)$$

The angle through which $A'B'$ rotates as it undergoes rigid body movement with B' deflecting δ_{i_1}, is

$$\theta_L = \frac{\delta_{i_1}}{(1-K)L} \qquad (13)$$

Combining these gives

$$\phi_{i_1} = \frac{(P_{\text{ULT}} - P_{y_1})(KL)^2(3-K)}{6EI(1-K)H_L} \qquad (14)$$

The curvature at ultimate load is equal to the curvature at first yield (Eq. (9)) plus the incremental curvature to ultimate (Eq. (14)) :

$$\frac{\phi_{\text{ULT}_1}}{\phi_{y_1}} = 1 + \frac{(P_{\text{ULT}} - P_{y_1})(KL)^2(3-K)}{6M_{y_1}(1-K)H_L} \qquad (15)$$

Rewriting in terms of the parameters K and m gives the rotation factor :

$$\left[\frac{\phi_{\text{ULT}_1}}{\phi_{y_1}} - 1\right]\frac{H_L}{L} = \frac{K(3-K) - m(2-K)}{6m(1-K)} \qquad (16)$$

Case 2.—The curvature due to moment at first yield is

$$\phi_{y_2} = \frac{M_{y_2}}{EI} \qquad (17)$$

After the first hinge has formed at section 2, the beam acts as if simply supported, Fig. 5. Proceeding as before with a new datum for incremental loads only, the angle of discontinuity at the hinge is the angle between the tangent to beam $A'C'$ at C' and the new datum :

$$\theta_R = \frac{(P_{\text{ULT}} - P_{y_2})KL^2(1-K)(2-K)}{6EI} \qquad (18)$$

The increment of curvature at the hinge is

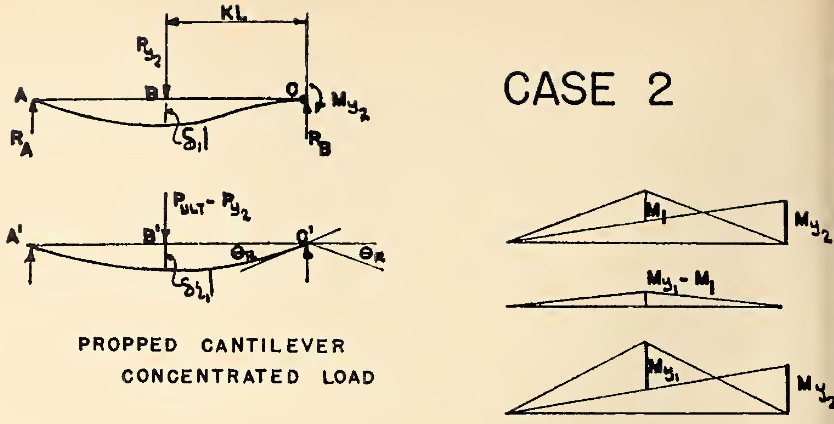


Fig. 5. Load-curvature relationship

$$\phi_{i_2} = \frac{\theta_R}{H_L} \qquad (19)$$

in which H_L is the hinge length at section 2. Similarly Eqs. (17) and (19) are combined into a rotation factor :

$$\left[\frac{\phi_{\text{ULT}_2}}{\phi_{y_2}} - 1\right]\frac{H_L}{L} = \frac{m(2-K) - K(3-K)}{6} \qquad (20)$$

A useful design tool has been developed in Fig. 6. The left half of this diagram presents the solutions of the equations for Case 1 failures. The rotation factor, given by Eq. (16), is plotted against the ratio of first yield to ultimate load, given by Eq. (7), for common values of the parameters K and m. Similarly the right half presents solutions for Case 2 failures, with Eq. (20) plotted against Eq. (8), inverted.

Propped Cantilever with Uniform Distributed Load.

Elastic Behaviour and Modes of Failure: Consider the same propped cantilever of span L, but now with a uniform distributed load, w, over its full span. For elastic behaviour, $0 < M \leq M_y$, the moments at the critical sections, are

$$M_1 = 0.0703wL^2 \qquad (21)$$

$$M_2 = 0.125wL^2 \qquad (22)$$

The ratio of first yield loads, w_{y_1} for Case 1 and w_{y_2} for Case 2 failure, is

$$\frac{w_{y_1}}{w_{y_2}} = 1.778m \qquad (23)$$

where $0 < m \leq 1.0$.

For a Case 1 failure

$$\frac{w_{y_1}}{w_{y_2}} < 1.0 \quad \text{and} \quad m < 0.565.$$

When $m > 0.565$ a Case 2 failure results and the mechanism forms when $m = 0.565$.

Inelastic Behaviour — Moments and Loads: The modes of failure are of course identical to the previous case analysed. From considerations of equilibrium, the relationship between ultimate load and yield moments, for a Case 1 failure, can be shown to be :

$$0.117w_{\text{ULT}}L^2 = M_{y_1} + (1-K)M_{y_2} \qquad (24)$$

The ratio of first yield to ultimate load, is

$$\frac{w_{y_1}}{w_{\text{ULT}}} = \frac{1.664m}{(m+1-K)} \qquad (25)$$

where K locates the hinge from the continuous support and is equal to 0.625 for a Case 1 failure.

The ultimate load for a Case 2 failure, is

$$0.5K(1-K)w_{\text{ULT}}L^2 = M_{y_1} + (1-K)M_{y_2} \qquad (26)$$

where $K = (1+m) - \sqrt{m^2+m}$. This expression has been derived from a consideration of the equilibrium existing between the external and internal work of the beam element.[9]

The load ratio, is

$$\frac{w_{y_2}}{w_{\text{ULT}}} = \frac{4K(1-K)}{(m+1-K)} \qquad (27)$$

Inelastic Behaviour — Curvatures and Rotations: Case 1.—Beyond first yield, the beam portion between the hinge and the continuous support acts as a cantilever with the distributed load $(w_{\text{ULT}} - w_{y_1})$. The other portion of the beam undergoes rigid body movement as in the previous case analysed, and additional bending as a simple beam due to the incremental load $(w_{\text{ULT}} - w_{y_1})$.

Proceeding as before, the angle of the tangent and the deflection at the free end of the cantilever, are

$$\theta_R = \frac{(w_{\text{ULT}} - w_{y_1})(0.625L)^3}{6EI} \qquad (28)$$

and

$$\delta_{i_1} = \frac{(w_{\text{ULT}} - w_{y_1})(0.625L)^4}{8EI} \qquad (29)$$

The angle of rotation of the left beam portion at the hinge, is

$$\theta_L = \frac{w_{\text{ULT}} - w_{y_1})(0.625)^4L^3}{3EI} - \frac{(w_{\text{ULT}} - w_{y_1})(0.375L)^3}{24EI} \qquad (30)$$

which is the angle produced by rigid body movement reduced by the bending of the simple beam effect.

Combining these expressions in Eq. (10), the incremental curvature, is

$$\varphi_{i_1} = \frac{0.0893(w_{\text{ULT}} - w_{y_1})L^3}{EIH_L} \qquad (31)$$

and the rotation factor, is

$$\left[\frac{\phi_{\text{ULT}_1}}{\phi_{y_1}} - 1\right]\frac{H_L}{L} = \frac{0.287 - 0.508m}{m} \qquad (32)$$

where $0 < m \leq 0.565$.

Case 2.—Proceeding similarly the hinge angle of discontinuity, is

$$\theta_R = \frac{(w_{\text{ULT}} - w_{y_2})L^3}{24EI} \qquad (33)$$

The incremental curvature can be expressed in the form of Eq. (19) which is combined with the first yield curvature, Eq. (17), to give the rotation factor:

$$\left[\frac{\phi_{\text{ULT}_2}}{\phi_{y_2}} - 1\right]\frac{H_L}{L} = \frac{1}{3}\left[\frac{(m + 1 - K)}{4K(1 - K)} - 1\right] \qquad (34)$$

where the location of the hinge within the span is given by

$$K = (1 + m) - \sqrt{m^2 + m}$$

and $0.565 \leq m \leq 1.0$.

The solution of these expressions is greatly simplified by the use of Fig. 7. The left half of the diagram presents the solutions of all Case 1 failures, with Eq. (32) plotted against Eq. (25) for common values of the parameter m. Similarly the solutions for Case 2 failures are presented on the right with Eq. (34) plotted against Eq. (27).

INTERIOR SPANS

Fixed Beam with Concentrated Load

Elastic Behaviour and Modes of Failure: Consider a fixed beam of span L with a single concentrated load, P, applied at a point that is a variable distance KL from the right fixed end, see Fig. 8. For elastic behaviour, the moments at the critical sections, are

$$M_1 = 2PLK^2(1 - K)^2 \qquad (35)$$

the moment at the load, the moment at the left support.

$$M_{2L} = PLK^2(1 - K) \qquad (36)$$

which is a maximum when $K > (1 - K)$, and the moment at the right support

$$M_{2R} = PLK(1 - K)^2 \qquad (37)$$

which is a maximum when $K < (1 - K)$.

The modes of failure are slightly different due to the formation of a third hinge at the left support. A Case 1 failure is first yield at section 1, under the load, followed by yield at either section $2L$, the left support, or section $2R$, the right support, or simultaneously at both these sections. A Case 2 failure is first yield at section $2L$ or $2R$ followed by yield at section 1 and finally at the other support. The order in which the hinges form may be such that yield occurs at the other support with section 1 yielding last. Both have been termed Case 2 failures since initial failure occurs at, section $2L$ or $2R$, the supports. The mechanism mode of failure occurs when all critical sections yield simultaneously and $P_y = P_{\text{ULT}}$.

The ratio of first yield loads, are

$$\frac{P_{y_1}}{P_{y_{2L}}} = \frac{m}{2(1 - K)m_R} \qquad (38)$$

for $K > (1 - K)$, and

$$\frac{P_{y_1}}{P_{y_{2R}}} = \frac{m}{2K} \qquad (39)$$

for $K < (1 - K)$. Where

$$m = \frac{M_{y_1}}{M_{y_{2R}}} \quad \text{and} \quad m_R = \frac{M_{y_{2L}}}{M_{y_{2R}}}$$

and considering only $0 < m_R \leq 1.0$ since the behaviour is similar when $M_{y_{2L}} \geq M_{y_{2R}}$.

These elastic expressions have been presented in Fig. 8 for $m_R = 1.0$ and greatly facilitate the determination of the section of first yield for all values of the parameters K and m. For $m_R < 1.0$ the values from Fig. 8 can be increased by $1/m_R$ to determine the mode of initial failure.

Inelastic Behaviour — Moments and Loads: From equilibrium, the ultimate load expressed in terms of the yield moment capacities, is

$$P_{\text{ULT}}KL(1 - K) = M_{y_1} + M_{y_{2L}} + (1 - K)(M_{y_{2R}} - M_{y_{2L}}) \qquad (40)$$

and the load ratio, for a Case 1 failure, is

$$\frac{P_{y_1}}{P_{\text{ULT}}} = \frac{m}{2K(1 - K)(m + 1 - K + Km_R)} \qquad (41)$$

Similarly for a Case 2 failure the load ratio, is

$$\frac{P_{y_2}}{P_{\text{ULT}}} = \frac{m_R}{K(m + 1 - K + Km_R)} \qquad (42)$$

Inelastic Behaviour — Curvatures and Rotations: Case 1.—Beyond first yield at section 1, the two elastic portions of the beam behave as cantilevers sharing the differential load $(P_R - P_{y_1})$, where $P_{y_1} < P_R < P_{\text{ULT}}$. Since the deflection at the hinge is that at the free end of each cantilever, their elastic deflection expressions can be equated giving a relationship between the reactions produced at the supports of the cantilevers:

$$R_{2L} = \frac{K^3}{(1 - K)^3} \cdot R_{2R} \qquad (43)$$

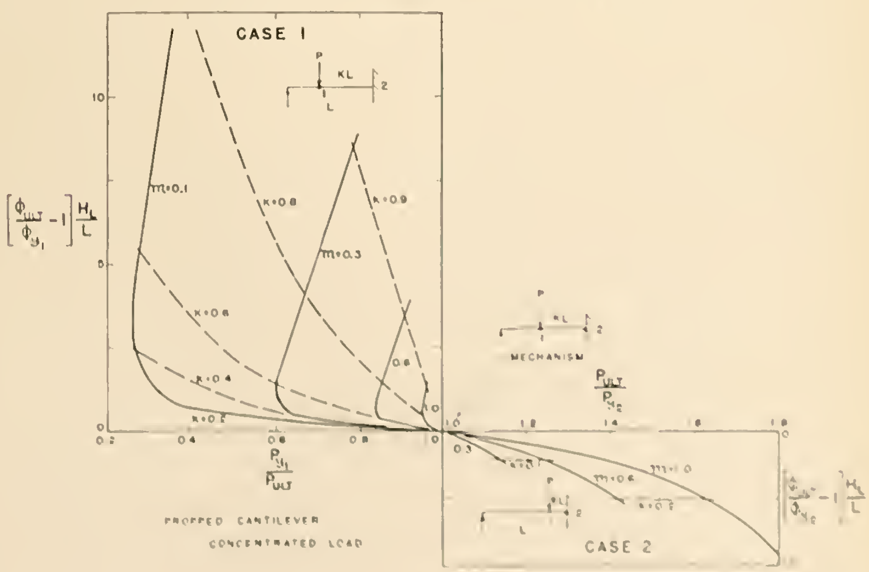
where $R_{2L} + R_{2R} = (P_R - P_{y_1})$. Now consider the static equilibrium of each cantilever the reaction

$$R_{2L} = \frac{M_{y_{2L}}}{(1 - K)L} \quad \text{and} \quad R_{2R} = \frac{M_{2R}}{KL}$$

which when combined with the previous expressions yields:

$$M_{2R} = \frac{(1 - K)^2}{K^2} \cdot M_{y_{2L}} \qquad (44)$$

Fig. 6. Rotation factor vs first yield load ratio



The angles produced at the hinge by the deflection of the two cantilevers under the differential load $(P_{y_{2L}} - P_{y_1})$, is

$$\theta_L = \frac{M_{y_{2L}}(1 - K)L}{2EI} \tag{45}$$

for the left cantilever and for the right cantilever:

$$\theta_R = \frac{M_{2R}KL}{2EI} = \frac{M_{y_{2L}}(1 - K)^2 L}{2KEI} \tag{46}$$

It has been assumed that yield occurs at section $2L$ and finally at section $2R$. The behaviour is similar if section $2R$ yields and then $2L$ last.

After first yield at section $2L$ the left portion of the beam undergoes rigid body movement while the right portion continues to act as a cantilever. The additional angles of discontinuity produced at the hinge, are

$$\theta_L' = \frac{(P_{\text{ULT}} - P_{y_{2L}})K^3L^2}{3(1 - K)EI} \tag{47}$$

and

$$\theta_R' = \frac{(P_{\text{ULT}} - P_{y_{2L}})K^2L^2}{2EI} \tag{48}$$

The total curvature, is

$$\phi_{\text{ULT}_1} = \phi_{y_1} + \frac{\theta_L + \theta_L' + \theta_R + \theta_R'}{H_L} \tag{49}$$

Combining the expressions developed in Eq. (49) the rotation factor in terms of the parameters K, m, and m_R, is

$$\left[\frac{\phi_{\text{ULT}_1}}{\phi_{y_1}} - 1\right]\frac{H_L}{L} = \frac{(1 - K)^2 m_R + K(3 - K)}{6(1 - K)m} \tag{50}$$

where $0 < m_R \leq 1.0$ and $0 < m \leq 1.0$.

The rotation requirements at the second hinge to form, section $2L$, can be shown to be:

$$\phi_{\text{ULT}_{2L}} = \phi_{y_{2L}} + \frac{\theta_L'}{H_L} \tag{51}$$

where H_L is the hinge length at section $2L$, and the rotation factor, is

$$\left[\frac{\phi_{\text{ULT}_{2L}}}{\phi_{y_{2L}}} - 1\right]\frac{H_L}{L} = \frac{K^2 - (1 - K)^2 m_R}{3(1 - K)m_R} \tag{52}$$

for $0 < m_R \leq 1.0$.

Case 2.—Beyond first yield at section $2L$ behaviour may be such that section 1 yields and finally section $2R$, or section $2R$ and then section 1.

Consider the first of the above modes of failure. After first yield at section $2L$ the behaviour is that of a propped cantilever with the load $(P_R - P_{y_{2L}})$ and the angle of discontinuity at the hinge is the angle of the tangent to the propped cantilever

$$\theta_{2L} = \frac{(P_{y_1} - P_{y_{2L}})K^2(1 - K)L^2}{4EI} \tag{53}$$

When yield has occurred at section 1, the left portion undergoes rigid body movement and the right portion acts as a cantilever, this being the same behaviour as the Case 1 failure of the propped cantilever. The hinge angle, is

$$\theta_{2L}' = \frac{(P_{\text{ULT}} - P_{y_1})K^3L^2}{3(1 - K)EI} \tag{54}$$

The incremental curvature at the hinge, is

$$\phi_{i_{2L}} = \frac{\theta_{2L} + \theta_{2L}'}{H_L} \tag{55}$$

and the rotation factor:

$$\left[\frac{\phi_{\text{ULT}_{2L}}}{\phi_{y_{2L}}} - 1\right]\frac{H_L}{L} = \frac{[3(1 - K) - 2K(2 - K)]m + 2K^2(3 - K)}{6(1 - K)(3 - K)m_R} \tag{56}$$

For the second mode of failure, the behaviour is that of a propped cantilever with a Case 2 failure. Now the angle at the hinge is

$$\theta_{2L} = \frac{(P_{y_{2R}} - P_{y_{2L}})K^2(1 - K)L^2}{4EI} \tag{57}$$

Simple beam behaviour results, after yield at $2R$, and the angle of the tangent at the left support, is

$$\theta_{2L}'' = \frac{(P_{\text{ULT}} - P_{y_{2R}})K(1 - K^2)L^2}{6EI} \tag{58}$$

Combining these, as in Eq. (55), results in the rotation factor:

$$\left[\frac{\phi_{\text{ULT}_{2L}}}{\phi_{y\,L}} - 1\right]\frac{H_L}{L} = \frac{(1 - K)m - K^2}{6m_R} \tag{59}$$

The solution of the expressions developed are presented in Fig. 9, for $m_R = 1.0$, with Case 1 failures on the left, Eq. (50) plotted against Eq. (41), and on the right for Case 2 failures, Eq. (56) versus Eq. (42), for common values of the parameters K and m.

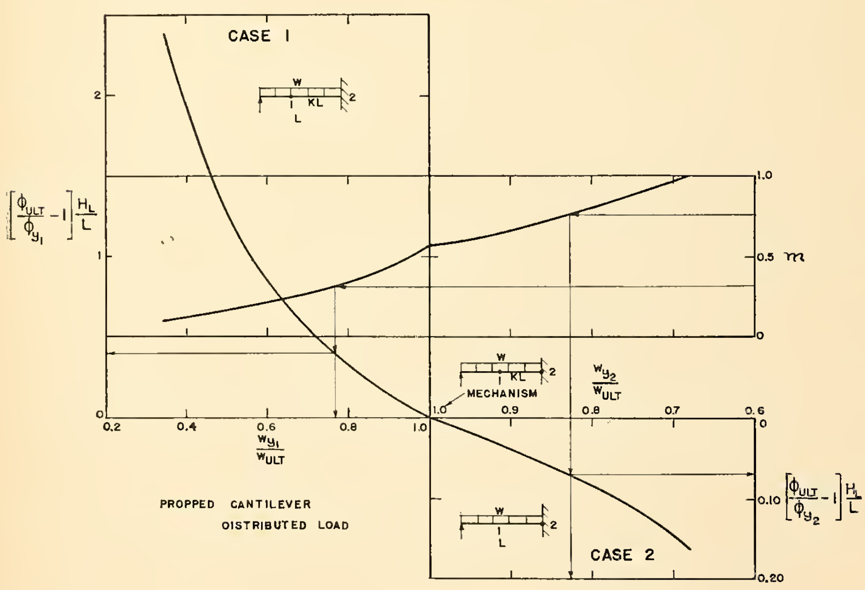
Behaviour after first yield at section $2L$ is that of a propped cantilever. The rotation requirements at the second hinge to form, when section 1 is that for a Case 1 failure, Eq. (16), and when section $2R$ is that for a Case 2 failure, Eq. (20). Fig. 6 may be used in their solution where the load ratios are now

$$\frac{P_{y_1} - P_{y_{2L}}}{P_{\text{ULT}} - P_{y_{2L}}} \quad \text{for Case 1}$$

and

$$\frac{P_{\text{ULT}} - P_{y_{2L}}}{P_{y_{2R}} - P_{y_{2L}}} \quad \text{for Case 2.}$$

Fig. 7. Rotation factor vs first yield load ratio



Fixed Beam with Uniform Distributed Load

Elastic Behaviour and Modes of Failure: Consider the same fixed beam of span L, but now with a uniform distributed load, w, over its full span, see Fig. 10. For elastic behaviour, the moments at the critical sections, are

$$M_1 = 0.0417wL^2 \quad (60)$$

$$M_{2L} = M_{2R} = 0.0833wL^2 \quad (61)$$

The ratio of first yield loads, are

$$\frac{w_{y_1}}{w_{y_{2L}}} = \frac{2m}{m_R} \quad (62)$$

and
$$\frac{w_{y_1}}{w_{y_{2R}}} = \frac{2m}{m_L} \quad (63)$$

where $< m_R \leq 1.0$ and

$$m_L = \frac{M_{y_{2R}}}{M_{y_{2L}}} \quad \text{for} \quad M_{y_{2L}} \geq M_{y_{2R}}.$$

It can be seen from Fig. 10 that these modes of failure are similar and only Eq. (62) therefore will be considered.

Fig. 10 presents the solutions for the above expressions from which the mode of failure can be determined for all values of the parameters m and m_R.

Inelastic Behaviour — Moments and Loads: The modes of failure are similar to the previous beam element analysed. The ultimate load, for a Case 1 failure, is $0.125L^2w_{ULT}$

$$= M_{y_1} + 0.5(M_{y_{2L}} + M_{y_{2R}}) \quad (64)$$

with a hinge located at the mid-span and the load ratio :

$$\frac{w_{y_1}}{w_{ULT}} = \frac{6m}{2m + m_R + 1} \quad (65)$$

For a Case 2 failure, the ultimate load, is

$$0.5K(1 - K)L^2w_{ULT} = M_{y_1} + M_{y_{2L}} + (1 - K)(M_{y_{2R}} - M_{y_{2L}}) \quad (66)$$

where the location of the hinge within the span is given by $K = 0.625$ when section 1 is the second hinge to form, and $K = (1 + m) - \sqrt{m^2 + m}$ when section $2R$ forms after first yield at section $2L$.

The load ratio, is

$$\frac{w_{y_{2L}}}{w_{ULT}} = \frac{6m_RK(1 - K)}{m + 1 - K + Km_R} \quad (67)$$

Inelastic Behaviour — Curvatures and Rotations: Case 1.—After first yield, behaviour is that of two cantilevers with load $(w_R - w_{y_1})$, where $w_{y_1} < w_R < w_{ULT}$. Proceeding in a similar manner as the previous analysis, it can be shown that the angles of discontinuity at the hinge, are

$$\theta_L = \theta_R = \frac{(w_{y_{2L}} - w_{y_1})(0.5L)^3}{6EI} \quad (68)$$

when section $2L$ yields.

The left portion of the beam now undergoes rigid body movement as well as additional bending as a simple beam with load $(w_{ULT} - w_{y_{2L}})$ when section $2R$ yields. The right portion continues to behave as a cantilever with

$$(w_{ULT} - w_{y_{2L}})$$

as load. The angles produced at the hinge, are

$$\theta_L' = \frac{(w_{ULT} - w_{y_{2L}})(0.5L)^3}{8EI} - \frac{(w_{ULT} - w_{y_{2L}})(0.5L)^3}{24EI} \quad (69)$$

and

$$\theta_R' = \frac{(w_{ULT} - w_{y_{2L}})(0.5L)^3}{6EI} \quad (70)$$

Combining these expressions in Eq. (49), the rotation factor, is

$$\left[\frac{\phi_{ULT_1}}{\phi_y} - 1\right]\frac{H_L}{L} = \frac{4(m_R - 2m) + 3(1 - m_R)}{12m} \quad (71)$$

for $0 < m_R \leq 1.0$ and $0 < m \leq 1.0$.

The rotation required at the second hinge, section $2L$, is given by Eq. (51) and the rotation factor :

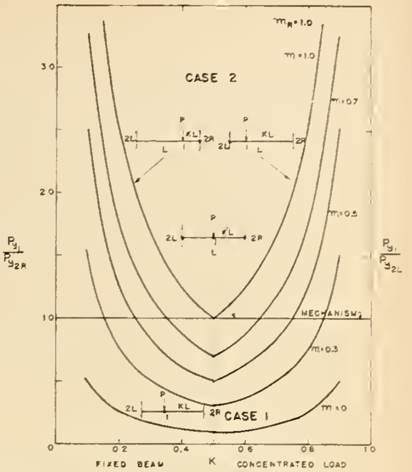


Fig. 8. First yield load ratio vs load position

$$\left[\frac{\phi_{ULT_{2L}}}{\phi_{y_{2L}}} - 1\right]\frac{H_L}{L} = \frac{(1 - m_R)}{12m_R} \quad (72)$$

Case 2.—After first yield at section $2L$, behaviour may be such that section 1 yields next, a Case 1 failure for the propped cantilever, with load $(w_{y_1} - w_{y_{2L}})$ or a Case 2 propped cantilever failure may result next with load $(w_{y_{2R}} - w_{y_{2L}})$. Proceeding as before, it can be shown that the rotation factors for the first of these modes, is

$$\left[\frac{\phi_{ULT_{2L}}}{\phi_{y_{2L}}} - 1\right]\frac{H_L}{L} = \frac{0.159 - 0.033m - 0.371m_R}{m_R} \quad (73)$$

and for the other mode :

$$\left[\frac{\phi_{ULT_{2L}}}{\phi_{y_{2L}}} - 1\right]\frac{H_L}{L} = \frac{1}{2}\left[\frac{m + 1 - K + Km_R}{6K(1 - K)m_R} - \frac{1}{3m_R} - 1\right] \quad (74)$$

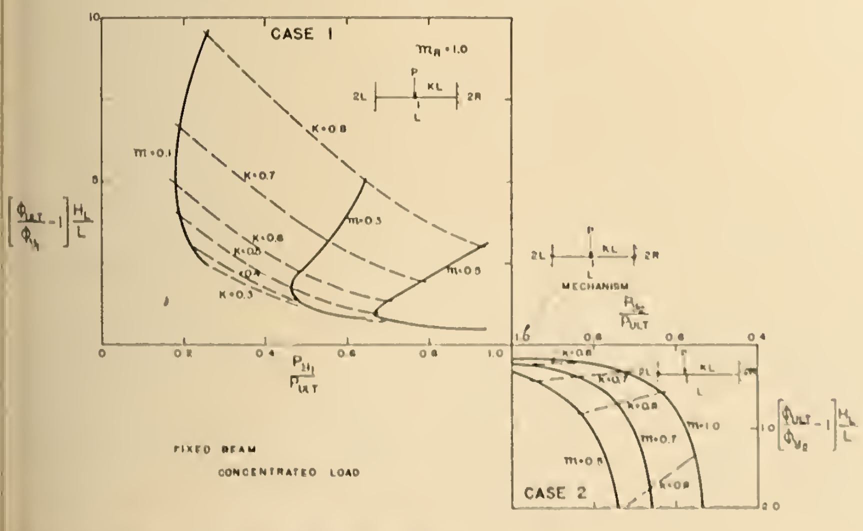
where $K = (1 + m) - \sqrt{m^2 + m}$

The solutions of the expressions developed are presented in Fig. 11, with Case 1 failures on the left, Eq. (71) versus Eq. (65), and for Case 2 failures, Eq. (73) versus Eq. (67), for common values of the parameters m and m_R shown.

The behaviour after first yield, section $2L$, is that of a propped cantilever and rotations required at the second hinge is that for a Case 1 failure, Eq. (32), when section 1 yields and for a Case 2 failure, Eq. (34), when section $2R$ yields. Fig. 7 may be used in the solutions where the load ratios become

$$\frac{w_{y_1} - w_{y_{2L}}}{w_{ULT} - w_{y_{2L}}} \quad \text{and} \quad \frac{w_{y_{2R}} - w_{y_{2L}}}{w_{ULT} - w_{y_{2L}}}$$

Fig. 9. Rotation factor vs first yield load ratio



respectively.

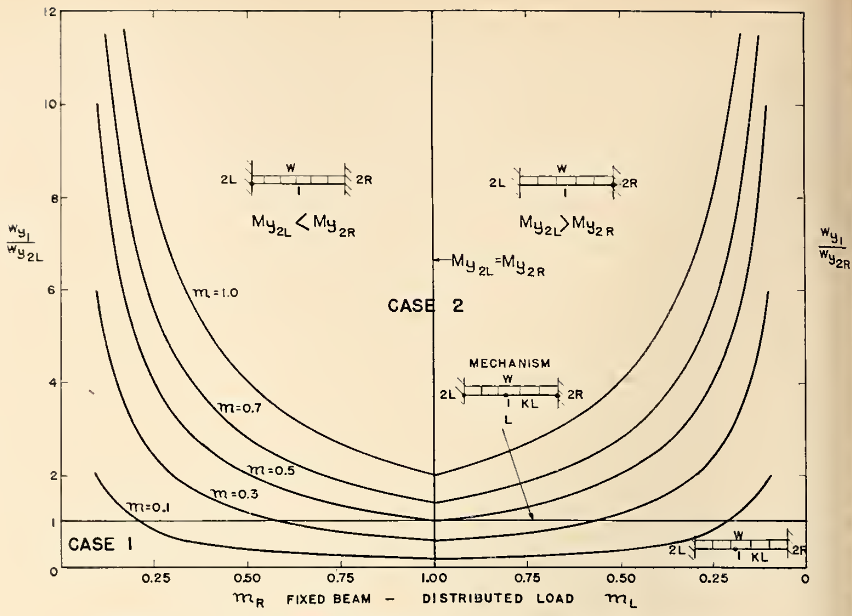


Fig. 10. First yield load ratio vs support yield moment ratio

Moment and Rotation Capacities in Reinforced Concrete

The theoretical basis and experimental verifications of the expressions for moment and rotation capacities of reinforced concrete sections have been sufficiently established to permit their presentation without lengthy development.[3,4,5,6]

Tension Reinforcement only: The yield Moment Capacity developed from the usual elastic theory

$$M_y = q_y b d^2 f_c\left(1 - \frac{k}{3}\right) \qquad (75)$$

in which

$$q_y = \frac{p f_y}{f_c}$$

a parameter describing the effective percentage of steel and the other symbols have their normal significance. The Ultimate Moment Capacity[7]

$$M_{\mathrm{ULT}} = q_y b d^2 f_c'(1 - 0.59 q_y) \qquad (76)$$

and the Rotation Capacity for design[1,2]

$$\frac{\phi_{\mathrm{MAX}}}{\phi_y} = \frac{1}{4 q_y^2} \qquad (77)$$

Combined Tension and Compression Reinforcement: The Yield Moment Capacity

$$M_y = \frac{f_c k' b d^2}{2}\left(1 - \frac{k'}{3}\right) + A_s' f_s' k'' d \qquad (78)$$

and

$$M_{\mathrm{ULT}} = b d^2 f_c' q_u'(1 - 0.59 q_u') + q' f_y' k'' b d^2 \qquad (79)$$

where

$$q_u' = \frac{p f_{su} - p' f_y'}{f_c'} \qquad (80)$$

The Rotation Capacity

$$\frac{\phi_{\mathrm{MAX}}}{\phi_y} = \frac{1}{5 q_y q_u'} \qquad (81)$$

The Effect of Variation in Continuous Support Fixity

In the analyses presented the assumption of fixed ends at the continuous supports was made. In the case of interior spans of a continuous beam this situation obtains when adjacent interior spans are of identical symmetrical loading and span length. The arrangement of load and span length of exterior spans and their adjacent interior spans may be such as to produce a fixed end effect at the common support. However, in the majority of cases the tangent at the continuous support will be other than that of a fixed end. This fact would seem to limit the usefulness of the solutions presented.

The collapse mechanism and ultimate load are dependent on the moment capacities of the critical sections and the load position (parameters K and m) and independent of the degree of fixity (f) at the continuous supports. The degree of fixity at the supports controls the value of the elastic moments at the critical sections as well as the mode of failure to some extent.

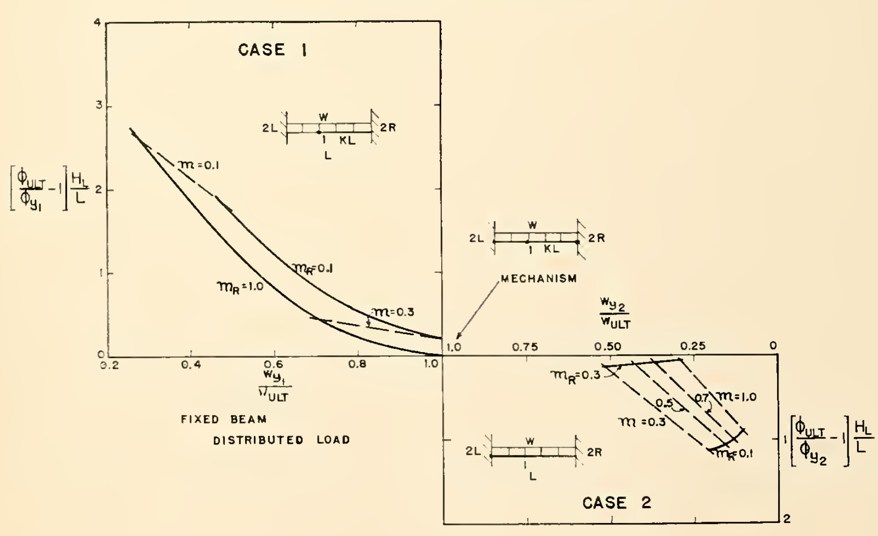
Consider the case of an exterior span with a single concentrated load and with fixity at the continuous support less than that of a fixed end, $f < 1.0$. The moment at section 2 is

$$M_2 = \frac{fPLK(1 - K)(2 - K)}{2}$$

and the moment at section 1 has been increased as shown by the lower dashed line in the bending moment diagram of Fig. 1. For a Case 1 failure, first yield at section 1 occurs sooner than when $f = 1.0$, and a somewhat greater rotation capacity is required in order that the collapse mechanism forms. For a Case 2 failure the rotation required is reduced as well as the possibility of its occurrence.

When $f > 1.0$, the elastic moments at the critical sections are defined by the upper dashed line in Fig. 1. The moment at section 2 builds up to its yield capacity more rapidly than when $f = 1.0$ and requires additional rotation capacity to permit the formation of the collapse mechanism. Similarly there is a reduc-

Fig. 11. Rotation factor vs first yield load ratio



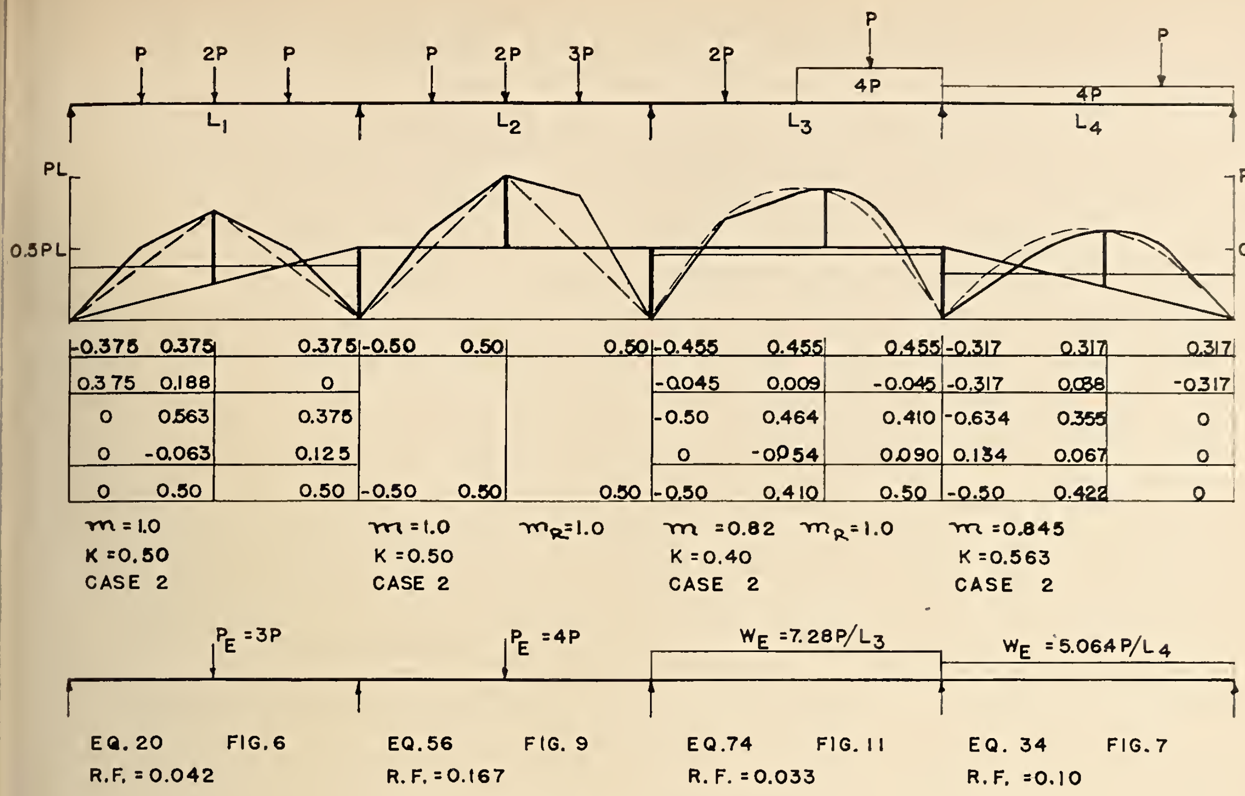


Fig. 12. Limit design problem

ion in the required rotation for a Case 1 ailure.

In general, the reduction of fixity at one of the continuous supports increases the required rotation at section 1 while the increase in fixity increases the rotation required at that support for the formation of the collapse mechanism.

The value of the rotation factor, as obtained from Fig. 6 or similar diagrams, is used to compute the required rotation capacity (ϕ_{ULT}/ϕ_y) of a critical section. A conservative design value for the hinge length (H_L) is the effective depth (d) of the section.[1] For ideal elastic-plastic behaviour the hinges are assumed to be concentrated at a single section. However, the actual hinge length is some finite length of beam due to the redistribution of stresses producing yield of adjacent sections. In the case of an elastic-strain hardening material such as reinforced concrete the hinge length may be determined from the bending moment diagram at the actual ultimate load, when M_{ULT} of the critical sections is reached. The hinge forms at M_y and all sections with greater moment comprise the hinge. The portion of beam undergoing yielding will be much larger than the effective depth and the required rotations thus less than when computed on the basis of $H_L = d$.

However, when the above factors are considered as well as the uncertainties normally associated with reinforced concrete it would seem prudent to increase the required rotations by a safety factor. The required rotations computed with $H_L = d$. The writer does not feel that a specific value can be quoted at this time as further analysis is necessary to determine the maximum variations that occur.

Application of Limit Design Method

Consider the design of the continuous beam shown in Fig. 12. The yield moment capacities required at the critical sections, at ultimate load, can be determined by the usual design procedures of the Plastic Design Theory.[8,9]

The simple beam bending moments are drawn for each span (Fig. 12). The assumption is made of fixed beam collapse mechanisms, in each span (horizontal fixing lines). The coefficients for these moments are shown below the bending moment diagram. Using the plastic moment distribution or moment balancing method, the appropriate adjustments are made to the moments at the ends of the beam. The moments at the interior supports are balanced and the resulting moments are the yield moment capacities required at the critical sections. Parameters m and m_R are computed. The location of the hinge (K) and the mode of failure are noted.

To determine the required rotation capacities at the critical sections, the actual simple beam bending diagrams are approximated by the bending moment diagram of one of the continuous beam elements analysed. The actual loads are considered replaced by an equivalent load (P_E or w_E) having the same maximum bending moment. (Dashed lines in bending moment diagram.)

The required rotations computed on this basis are conservative. The portions of the bending moment diagram neglected would tend to increase the curvature of the elastic beam portions reducing the hinge angles and the required rotations in most cases. The use of a factor of safety and the larger actual hinge lengths would tend to offset any shortcomings of the method.

Reinforced concrete sections can be proportioned using the moment and rotation capacity expressions presented.

References

1. **Application of Plastic Design Theory to Reinforced Concrete Continuous Beams**, by C. Berwanger, M.Sc. Thesis, Queen's Univ., 1957.
2. **Limit Design of Reinforced Concrete Beams** by C. Berwanger and D. T. Wright, **Proceedings**, ASCE, Vol. 86, No. 2541, July, 1960.
3. **Concrete Stress Distribution in Ultimate Strength Design**, by E. Hognestad, N. W. Hanson, and D. McHenry, ACI Journal, Vol. 27, No. 4, December, 1955, pp 455-479.
4. **Elastic-Plastic Design of Single Span Beams and Frames**, by H. A. Sawyer, **Proceedings**, ASCE, Vol. 81, No. 851, December, 1955
5. **The Ultimate Load-Theory Applied to the Design of Reinforced and Prestressed Concrete Frames**, by A. L. L. Baker, Concrete Publications, 1956
6. **Plastic Hinging at the Intersection of Beams and Columns**, by G. C. Ernst, ACI Journal, Vol. 28, No. 12, June, 1957, pp. 1119-1144
7. **An Investigation of the Load-Deformation Characteristics of Reinforced Concrete Beams up to the Point of Failure**, by J. R. Gaston, C. P. S[illegible], and N. M. Newmark, C. E. Studies, Univ. of Illinois, No. 40.
8. **Plastic Design of Steel Frames** by L[illegible] S. Beedle, John Wiley & Sons [illegible] 1958
9. **Plastic Design of Portal Frames** by Jacques Heyman, Cambridge University Press, 1957

EIC

CIVIL ENGINEERING EDUCATION

S. D. Lash, M.E.I.C.,
Head, Department of Civil Engineering, Queen's University, Kingston, Ont.

THE PURPOSE of a civil engineering course is to prepare young men to enter the profession of civil engineering. There have been many definitions of civil engineering and perhaps the best known will be found in the Charter of the Institution of Civil Engineers (1828) where the objects of the Institution were defined as:

"The general advancement of Mechanical Science and more particularly the acquisition of that species of knowledge which constitutes the profession of a Civil Engineer, being the art of directing the great sources of Power in Nature, for the use and convenience of man . . ."

In a recent paper, Wilbur[1] has suggested that the purpose of civil engineering is "the fulfillment of human needs through the adaptation and control of the land-water-air environment". Since both these definitions say essentially the same thing we may conclude that the basic aims of the civil engineer are much the same today as they were 130 years ago.

Is civil engineering an art or a science? The Charter of the Institution speaks of both—"the general advancement of Mechanical *Science*" and "the *art* of directing the great sources of power . . ." More recently the Institutions of Civil, of Mechanical and of Electrical Engineers have stated—

"Engineering is largely based on science but is not itself an exact science; it is also in varying degrees an art. The engineer must therefore be educated in the scientific principles of his profession and trained in its practice".[2] It seems clear therefore that engineering is both an art and a science and that the engineer should be regarded as neither artist nor scientist but as a member of a profession in which art and science are integral parts of a coherent discipline.

Telford and his associates regarded themselves as members of a profession. An examination of some of the reports of meetings of the Institution of Civil Engineers held during the 1830's shows that engineers at that time were concerned with advancing their own knowledge through pooling their experiences, but there is nothing to indicate that they were concerned about their professional status. On the other hand, engineers within recent times have shown an almost pathological desire for status. They have ardently wished to be considered members of a profession comparable in social position to the established professions of Law, Medicine and the Church. In an attempt to accomplish this, they succeeded in persuading provincial legislatures to establish licensing bodies and to restrict the practice of engineering to those who were duly licensed. The ostensible reason for this legislation was to protect the public, but most engineers saw it as a way of enhancing their status and their earnings. It was at this time that the unfortunate term "professional engineer" was either invented, or more likely imported from the U.S.A. Among the established professions, it is only engineers who consider that the public will not recognize their professional status unless it is blatantly stated.

Recent events in Ontario have demonstrated clearly that in spite of provincial legislation, many angry young men who are permitted by law to call themselves professional engineers are still status seekers. Perhaps their anger reflects their disappointment in discovering that professional engineering is not what it claims to be. They find that their work does not measure up to the description of the work of a professional engineer, adopted by the Eusec conference, which reads in part as follows:

"His work is predominantly intellectual and varied and not of a routine mental or physical character, but requires the exercise of original thought, and if necessary, the responsibility for supervising the technical and administrative work of others".[3] Few of these young engineers measure up to the requirements listed in the second and third paragraphs of that definition:

"His education will have been such as to make him capable of closely and continuously following all progress in his branch of engineering science by consulting newly published work on a worldwide basis, assimilating this information and applying it independently. He must be able to make contributions to the development of engineering science and its application.

"By virtue of his education and training he will have acquired a broad and general appreciation of the engineering sciences as well as a thorough insight into special features of his own branch, with the result that in due time he can give authoritative technical adviee, or be responsible for the direction of important tasks in his branch".[3]

It appears that the universities in Canada are engaged in training two groups of people — one an élite who will in due course become professional engineers in the true or "Eusec" sense of the word, and the other much larger group who will be engaged in a variety of activities, many of a sub-professional character or only slightly connected with engineering. Other professional schools, such as teaching and medicine for example, are engaged in training people who will become full and active members of their respective professions. We do not expect a qualified doctor to take a job as a salesman, but we see nothing wrong in a qualified engineer taking a position as a "sales engineer".

Realistic appraisal therefore of the position of the graduate civil engineer in Canada will lead us to recognize that university training in civil engineering at the undergraduate level can do little more than lay the foundations of professional knowledge and provide a measure of education of a scientific kind above the high school level. The basic undergraduate course must consist of general education plus a broad program of engineering studies. Only in this way can the universities discharge their responsibilities to the engineering profession and to the students who throng their halls. In addition, a university must provide instruction of a technical character at an advanced level and must extend the frontiers of knowledge through research. These tasks are accomplished in its graduate school.

Let us now consider the traditional undergraduate course in the light of the foregoing principles. For purposes of discussion the subjects of instruction can be classified as follows:

(1) *General Education*
- (a) Mathematics.
- (b) Science—physics, chemistry, geology.
- (c) Arts—English, economics, politics.

(2) *Engineering Studies*

(a) Applied Science — mechanics of materials, properties of materials, soil mechanics, fluid mechanics, theory of structures, thermodynamics, engineering geology.
(b) Elementary Technology — drafting, surveying.
(c) Advanced Technology.
(d) Other – management, professional practice, law, town planning.

These formal studies must be supplemented by practical training before the graduate can be regarded as a civil engineer.

General Education

The subjects included under the heading of General Education are included in the curriculum for two reasons — firstly, to provide the basis for engineering studies, and secondly to give students a broad intellectual training. From the point of view of a civil engineering curriculum the latter is at least as important as the former. Much of the work covered in physics, chemistry and mathematics is never used in the subsequent undergraduate courses. In fact, the amount of basic science and mathematics required to comprehend an ordinary undergraduate course in civil engineering is quite small. Most of the recent advances in structural theory for example, have required little more than high school mathematics for an understanding.

As civil engineers, we must be very careful not to be infected by the disease known as "mathematecosis". The dangers of this disease have been clearly stated recently by two eminent structural engineers. Torroja has written:

"Structural design is concerned with much more than science and techniques; it is also very much concerned with art, common sense, sentiment, aptitude and enjoyment of the task of creating opportune outlines to which scientific calculations will add finishing touches, substantiating that the structure is sound and strong in accordance with the requirements.

Mathematics is merely a convenient tool by which the designer determines the physical proportions and details of a planned structure in order to transform his ideas from the lines of a blueprint to the actuality of a finished structure".[4]

Nervi has stated:

"The mastering of structural knowledge is not synonymous with a knowledge of those mathematical developments which today constitute the so-called theory of structures. It is the result of a physical understanding of the complex behaviour of a building, coupled with an intuitive interpretation of theoretical calculations. We cannot forget that in the distant past intuition allowed the execution of works which cannot be analysed today by the most modern theoretical methods, and before which we must bow in reverent and humble admiration".[5]

It is therefore a mistake to assume that a civil engineering curriculum can be improved by massive doses of mathematics or pure science. In a noteworthy presidential address to the Institute of Civil Engineers, delivered 20 years ago, Professor Charles Inglis of Cambridge University, said—"To a real expert, the type of mathematics utilized by engineers in their everyday work is hardly worthy of the name, but only a degraded form is debased by utilitarian considerations . . . Elaboration of mathematics in relations to engineering problems often betokens a paucity of physical conceptions".[6]

This does not mean that there is no place in the civil engineering profession for the student with high mathematical ability but it is clear that such ability by itself is not enough.

Similar arguments can be used in connection with physics. At Queen's, and I suspect at some other universities, the percentage of failures in physics is often greater than in other subjects, and sometimes reaches fantastic heights. Perhaps the time has come to take a new look at the place of physics in a civil engineering curriculum. It may be observed for example, that physics is not included in the curriculum at many English universities whereas at some Canadian universities more time in the first two years is given to physics than to any other subject. These differences can not be explained entirely by different entrance standards.

English is, or should be, a basic subject in any university course. One of the characteristics of an educated man is that he has the ability to communicate ideas and that he has some awareness of his literary heritage. Therefore the study of English means a study of the English language and not a course in report writing or letter writing. There has been a tendency in recent years to demand that engineers be taught the art of public speaking. It is questionable if the universities can do much in this matter and perhaps it is not necessary that they should. The young graduate should seldom be expected to make speeches.

Within the last decade we have seen a number of other subjects commonly, but loosely, called "humanities" included in engineering courses. The avowed reason for including these subjects is a desire to broaden the cultural background of engineers. It is questionable whether they have achieved this purpose. Although economics, politics and the like have been accepted as part of the curriculum there has been a lack of enthusiasm for them, especially by professors. A survey of opinions of Queen's graduates in civil engineering indicated that a majority felt that courses of this kind were not carried to a sufficiently advanced level. Moreover the average rating of the course content was only "fair" whereas many other subjects were rated "good" or "excellent". These *graduates* wished that they had received better and more extensive courses in English, politics and the like. Experience has shown however, that *students* will respond much more effectively to subjects that appear to be relevant to the practice of engineering. It is these subjects which should be studied. Politics for example, is relevant to civil engineering because many civil engineers are employed by governments, but philosophy is not, however admirable a study it may be for other reasons. Geography would appear to be an excellent subject for civil engineering students to study.

In a lecture delivered at Queen's University some years ago, Sir Richard Livingstone pointed out that the limitations of a strictly scientific education can be overcome "not by doling out snippets of history, literature and art but by enabling students to experience the impact of literature and art".[7] A university if it is to civilize engineers or anybody else must provide a civilized environment. This it can do through the beauty of its buildings and grounds, through the intellectual stimulus of lectures by outstanding authorities, through plays, concerts and the fine arts. Within recent times we have tended to overemphasize the mediocre and the immature and underestimate the value of distinction and wisdom. Discussion in the coffee shop may serve to pass the time but a lecture by an Oppenheimer may leave an indelible impression.

The proper time for general education is in the early years of the course. This is the practice in medicine and the law for example, and it appears to be the most logical arrangement. General education should precede specialization and those who can not attain a reasonable standard of general education should not be allowed to proceed with studies leading to professional status. On the other hand, the cultural stimulus of

the university should always be present though not always expressed in formal courses and measured by examinations.

The subjects classified as elementary technology such as drafting and simple surveying, are included in the first two years for two reasons. On the one hand they enable students to develop basic skills which they need and which are useful to them in summer jobs: on the other, the low philosophical content of these subjects makes them unsuitable for inclusion in the upper years.

Engineering Studies

The ability to apply scientific principles is the hallmark of a competent engineer and the heart of an engineering course is applied science. Pure science and mathematics are concerned essentially with abstractions whereas the engineer is concerned with real objects, with men and with money. Although many aspects of his profession can only be learnt through practical training and experience the foundations of scientific method must be laid by the university.

It is very important to recognize that applied science subjects are the *fundamental* subjects of engineering. They are characterized by a judicious balance of rigorous analysis and reasonable assumptions. Consider for example, the design of beams. The applied mathematician can tell us how to determine stresses in a simple cantilever beam. The solution is complicated involving the use of double infinite series. (see Timoshenko[8]). It becomes much more complicated if the beam is not of a simple geometrical cross-section and if loads are applied at a number of places along the beam. The engineer on the other hand, is able not only to analyze but also to design beams of all kinds of shapes supporting a great variety of loads, on the basis of the theory of simple bending.

The common complaint by civil engineering instructors is, not that students lack knowledge of science and mathematics, but that they are unable to apply the knowledge that they have acquired. The remedy is greater emphasis upon those subjects such as strength of materials, soil mechanics, and fluid mechanics in which mathematics is a useful tool.

Opinions differ concerning thermodynamics. Most students feel it to be irrelevant to a civil engineering course, but professors of mechanical engineering consider it an essential preliminary if students are to study heat engines and similar topics. The real problem is to decide whether it is necessary to include mechanical engineering in a civil engineering curriculum. This will be discussed later. The position is much clearer as far as geology is concerned. A lack of appreciation of geological structure has been the cause of many civil engineering troubles including major failures.

The increasing variety of materials available to the engineer and the increasing development of scientific knowledge concerning materials has resulted in a need for a more thorough study of the properties of materials. This intractible subject is of paramount importance.

There is always likely to be a considerable variety in the technological content of civil engineering courses. This variety reflects the interest of faculty members, the demands of employers, and to a limited extent, the interest of students.

In the excellent publication "American Civil Engineering Practice", by Abbett, there are 28 sections dealing with a range of subjects from Airport Engineering to Refuse Disposal and all of these have some claim to inclusion in an undergraduate eourse. Obviously, a selection must be made and it is necessary to choose both the number of subjects to be studied and the time to be spent on each subject. One does not reduce the number of subjects by giving them collective titles such as "Transportation Engineering". The subject receiving most time is structural design and this reflects the central position of construction in the civil engineering world. Structures form a vital part of most engineering works and consequently all civil graduates need to be acquainted with the rudiments of structural design. In spite of this there has been a tendency within the last decade to reduce the time spent on structural design and to increase the time spent on other technical subjects. This is largely a consequence of the growing importance of highway construction, and of the development of soil mechanics. It seems probable that more civil engineers are employed in highway engineering than in any other branch of civil engineering.

Half the graduates in civil engineering are likely to spend the first few years of their professional life in the construction industry. They are not likely to receive any extensive training aimed specifically at fitting them for this industry. There are two reasons for this — the most important is that those in universities believe that university lectures are no substitute for practical training; the second is the extreme diversity of the construction industry.

Graduates seldom complain about the absence of a specific technical subject but they are apt to be critical of the content of those subjects which were included in their studies. In some instances this criticism may be well founded, but one suspects that in many others it reflects their discovery that the subject is wider and deeper than they suspected.

In a large university it is possible for students to specialize in their final year and thus carry their studies in one field to a relatively advanced level. This, however, can only be done by reducing or eliminating the work in some other fields, and leaving gaps in their knowledge which some may consider serious. An alternative is to encourage students of superior ability to take additional courses in applied science or mathematics in order to provide a better foundation for graduate study or work in a design office.

In most universities, civil engineering students are exposed to one or more courses in mechanical or electrical engineering or both. To some extent these courses have lingered on from the days when civil engineering included all branches other than military engineering. They continue to be included beeause civil engineers may have responsibility for the operation of mechanical and electrical equipment. It seems to be very difficult to devise satisfactory courses in these subjects for civil engineers. They have little interest in either the design or the testing of mechanical equipment — basically they are only concerned with knowing what kind of equipment is likely to be used, what it does and what kind of environment it must have in order to work efficiently. Perhaps a new type of course is needed — one which combines a limited amount of basic theory with a fairly generous dose of practical applications.

Certain non-teehnical subjeets have been introduced in to civil engineering curricula from time to time in response to real or imagined needs. At Queen's University for example, these include business administration and town planning, and a subject mysteriously called engineering relations. None of these subjects is essential but all are of some value, though opinions are likely to differ concerning their relative importance. To the author, engineering relations which deals with standards of professional conduct and the legal aspects of engineering, is of greatest value, but it may be observed that most engineering students other than civil engineers get along quite well without such a course. There would seem to be sufficient reasons for offering most of these courses on an elective basis.

Many engineers are concerned with administration and it is frequently argued that more time should be given to this subject at the university. This is open to question. The primary purpose of a civil engineering course is to train civil engineers. Administration is a very wide field and little useful knowledge can be imparted in a single course. The Queen's survey has shown that the young graduate spends relatively little time on administration during the first five years after graduation though the percentage increases sharply thereafter. By the time he is really involved in administrative work either he will have forgotten what he was taught at the university or the subject will have changed materially. There are many opportunities through graduate study, professional development courses and the like for an engineer to develop his knowledge in those fields. This knowledge should be acquired in this way at an appropriate time by those who need it. We should not dilute our university courses and produce hybrid animals who will be inadequately trained in both engineering and management.

This does not mean that economies should be ignored. The saying that an engineer is one who can do for a dollar what any damn fool can do for two contains an element of truth. Economy, meaning least annual cost, is a basic consideration in most civil engineering projects though by no means the only one. Most instructors are fully aware of this and emphasize it at appropriate times and places.

Practical Experience

Nobody questions the need for practical experience as a part of the training of an engineer but summer experience is by no means necessary for a full appreciation of undergraduate courses.

It should be realized that the Canadian system of a long summer vacation is based more on alleged economic need than anything else. It can easily be shown that students would be further ahead financially if the present four-year course with three five-month vacations were telescoped into a three-year course with two two-month vacations. Those taking the compressed course would very likely be further along the road to professional status after four years than those taking the present course. It seems possible therefore that there would be merit in introducing a greater element of flexibility so that students who wish to take an accelerated course could do so.

Graduate Study

The technology of civil engineering has developed rapidly during the past few decades and it is important that full advantage be taken of all the knowledge now available. In the past, Canadian engineers have frequently been slow to make use of techniques developed elsewhere (except perhaps those developed in the United States) and comparatively little research in civil engineering problems has been carried out in Canadian universities. The universities were partly responsible for this state of affairs, but the situation has now changed to the extent that in the academic session 1960-1961, 204 students were registered as graduate students in civil engineering in Canadian universities. There is now a small but steady stream of graduates with higher degrees who have received rigorous training to a high level and who are capable of making substantial contribution to Canadian engineering if given suitable opportunities.

When graduate students were few, graduate study consisted mostly of research, since there were not enough students to justify offering graduate courses. Today, the emphasis has shifted to course work, partly because there are more students, but largely because there is much for students to learn before narrowing their studies down to research problems. At the same time, the amount of research going on in universities has increased enormously. This apparent contradiction is explained by the fact that it has now become usual for graduate students and some staff members to devote summer months to research. Much of this research is supported by grants from organizations outside the University. Good students are offered substantial incentives to continue their studies: professors are offered incentives to remain at the university for the summer months. Expensive apparatus becomes available.

Sponsored research has the advantage of enabling university staff and graduate students to maintain an awareness of the problems faced by practising engineers. At the same time it has certain limitations and it is unwise for a university to permit graduate studies to become over-dependent on sponsorship. The problems posed by sponsors may not be particularly suitable for study at a university and the solutions to such problems may be found slowly if at all. Research carried out for a sponsored project must usually be carried out sufficiently far to realize the objectives of the project, but such a project may be too elaborate and above all too lengthy for a thesis topic.

Traditionally, a Master's degree has required one year of full-time graduate study and a Doctor's degree a further two years. There is a danger that the work for a Master's degree may be extended to two years and that for a Doctorate to five or six years. In the long run such lengthy programs of study will be most harmful to the engineering profession. Only a few will be willing to spend the time, unless they were being well paid for doing so, and these will tend to lose touch with a practical world of engineering. Let us think therefore of the Master's program as being essentially a fifth year of study, highly specialized and one that can be successfully completed by a good student within a period of 12 months. This study will include a thesis, usually based on research, but most of the time during the academic sessions will be devoted to course work. For those who are not interested in research it seems reasonable to award a Diploma based on course work only. At the Doctorate level, (i.e. above the Master's level) graduate study should consist almost entirely of research and such research may often form a part of a sponsored program. Excessive length should be avoided and the Doctor's degree should be thought of as a training not only for those who expect to enter the teaching profession but also for those who will devote their high abilities to engineering practice.

In conclusion it may be suggested that the elements of a sound educational program in civil engineering are an adequate foundation of general education, a thorough grasp of applied science, and a knowledge of technology. There is room for a great variety in the latter, especially in the level to which technical studies are pursued. In the under-graduate course the fields of study are broad and the depth of study is necessarily limited. Graduate study is more limited in scope but greater in depth. It is neither necessary nor desirable that the university produce a standardised product. Surely the profession needs both the traditional kind of engineer and the more specialized, more scientifically minded engineer now coming from our graduate schools.

References

1 Wilbur, John B., **The Scope of Civil Engineering.** Paper presented at the Conference on Civil Engineering Education Ann Arbor, Michigan, July 1960
2 Proceedings of the Eusec Conference on Engineering Education, London 1953, p 73
3 Ibid. Page 78-79
4 Torroja, E., **Philosophy of Structures**, p. 1
5 Nervi, P. L., **Structures** p. 17, 24
6 Inglis, C., Presidential address, J. Institute of Civil Engineers, Vol 17 1941-2, p. 6
7 Livingstone, R. **Education and the Spirit of the Age**, p. 100
8 Timoshenko, S. **Theory of Elasticity** 1st Ed. p. 293

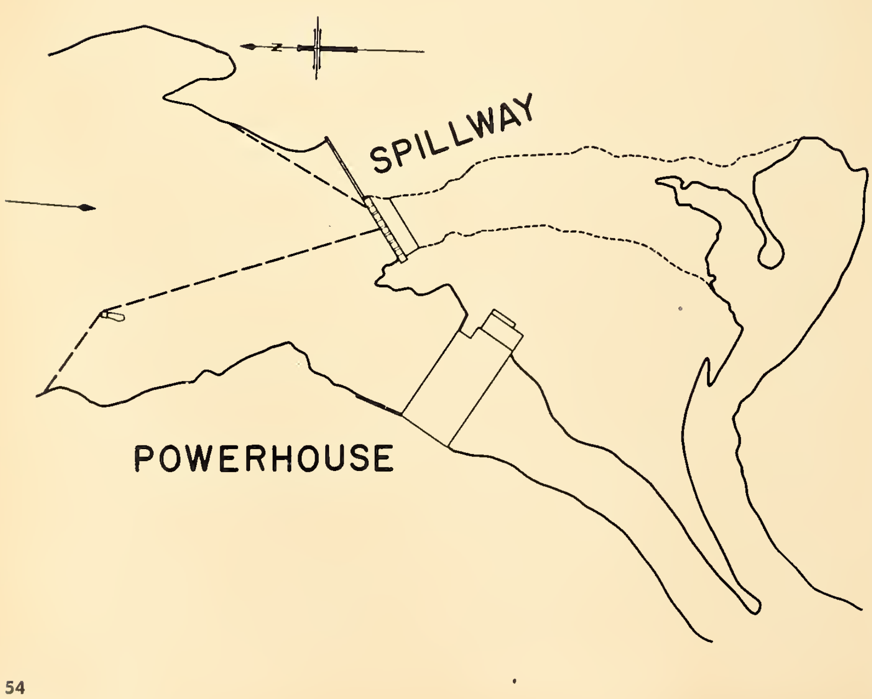
MODERN TECHNIQUES SOLVE UNUSUAL LOG DRIVING PROBLEM

D. M. Foulds, M.E.I.C.,
River Control Engineer

C. E. Davidge,
Hydraulic Model Engineer

The Hydro-Electric Power Commission of Ontario

Fig. 1.



ANYONE familiar with the development of hydro-electric power on rivers which are also used for log driving purposes will testify that the interests of the two entities are not always compatible. The power dam creates an obstacle to log driving even though the lake it creates may well reduce damage to logs previously caused by the rapids. On the other hand an appreciable percentage of the wood cut in the forest inevitably finds its way to the racks of the powerhouse and must be removed to prevent loss of generating capacity.

In the province of Ontario, under the terms of the Lakes and Rivers Improvement Act the owner of a dam, on a river where timber is usually floated, is required to provide a slide or apron for the passage of timber, and the logging companies look after the handling of the logs in the river. The difficulties which were encountered at the Cameron

Falls generating station on the Nipigon river are representative of those encountered where both entities must carry on their work simultaneously in a relatively narrow forebay. While the general problem is not new, it is suggested that the particular problem was an unusual one, and that the method of solution was also unusual. By combining the hydraulic experience of the Commission with the logging experience of the Abitibi Power and Paper Company a solution was developed in the laboratory which proved to be successful when tried in the river.

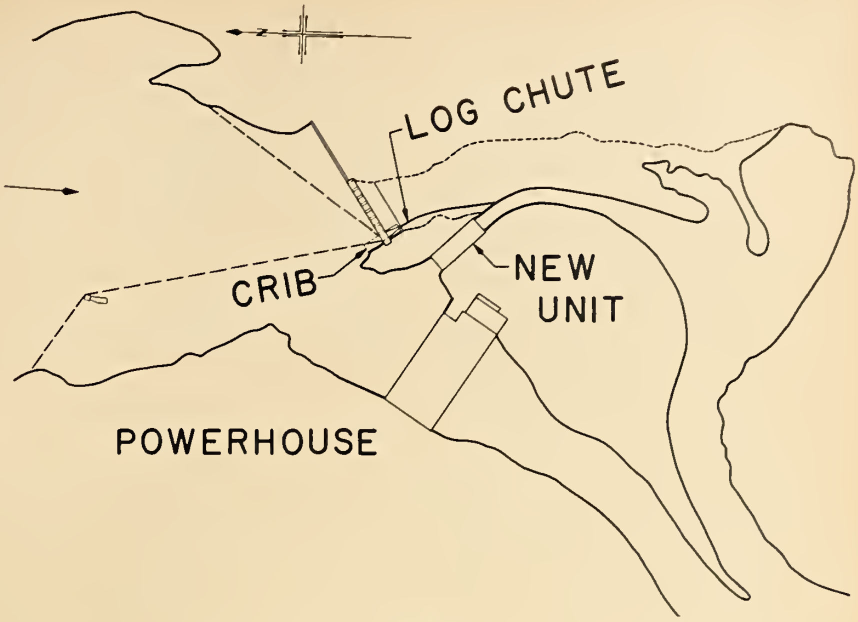


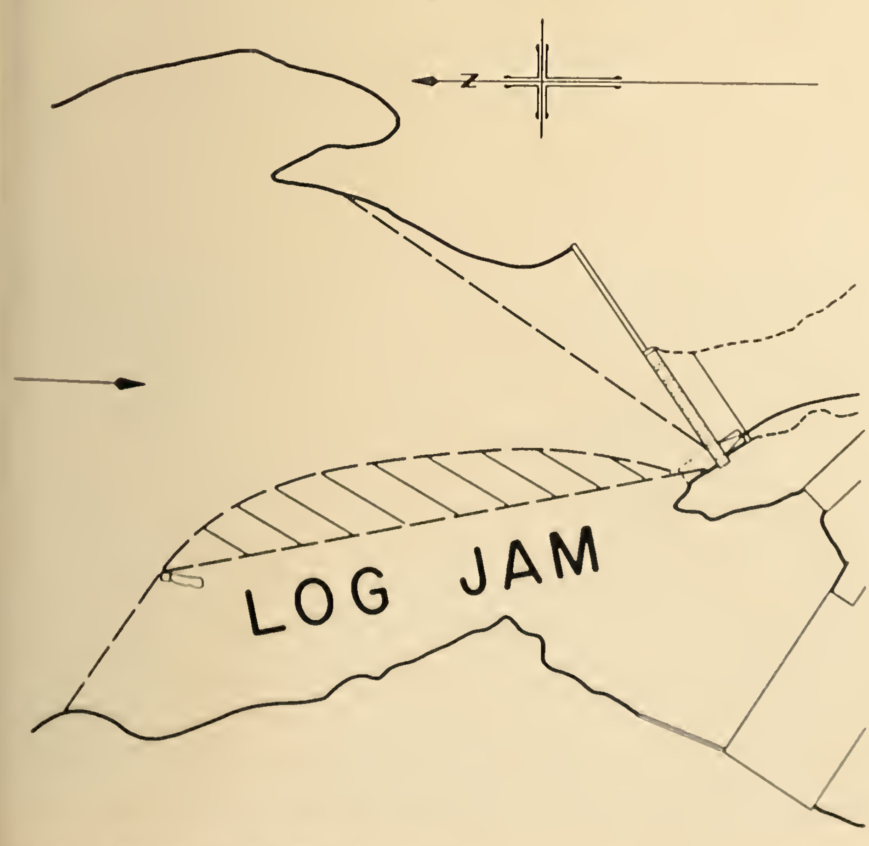
Fig. 2.

Background

Power was first developed at Cameron Falls more than 40 years ago and some 15 years later the Abitibi Co. commenced log driving operations. Almost all of the wood being moved was for the manufacture of pulp, cut into 8 ft. lengths, and averaging approximately 6 in. in diameter. It became the custom to pass this wood through three partially open stop-log sluices using guide booms connected to the piers of the spillway as shown on Fig. 1. A flow of approximately 2500 c.f.s. was required to create adequate rates of log movement and to prevent excessive damage from the rocks downstream of the spillway.

Initially, the time required to move the wood through the dam was short and the plant was not always required to operate at capacity. As the years passed, the demands for power increased, the demand for pulp was reaching 400,000 cords annually, and the log driving period was extended to a period of approximately five months. An adjacent water-shed was diverted into the Nipigon river to provide a source of additional power and when an additional generating unit was ultimately added to the powerhouse to make use of this water, the problem arose which is the subject of this paper.

Fig. 3.



Problem

The relative positions of the new unit and log chute are shown on Fig. 2 and it would appear that the point of land between the two could be expected to cause a natural division in the flow. An underwater crib was installed to increase the draw towards the chute, which was designed to operate satisfactorily with a flow of 700 c.f.s., or less than one third of that formerly required for log driving. To drive through the chute the booms were moved as shown and it was found that the rate of log passage through the structure was reduced to approximately one third of that which had existed before.

It was also found that large quantities of wood were passing under the booms and collecting in front of the racks of the powerhouse.

Causes of the Problem

Reports indicated there were several possible causes of the difficulties, including such factors as the location of the chute entrance and the lack of sufficient draw towards the entrance. It was considered that some clarification of these reports would be advisable and the author was dispatched to the site to observe and report. During discussions with the Cameron Falls operating staff and the

local representatives of the Company it evolved that a situation had been created which is illustrated by Fig. 3.

The large area shown by cross hatching was packed with logs to a depth of several feet and a steady stream of pulp logs was emerging from this packed area and proceeding to the racks of the powerhouse. The Company installed another boom on the east side of this jam in an effort to eliminate the rough edges and attempted to drive through the remaining area. Frequent jams occurred in the forebay causing log movement to be intermittent and it was found that the assistance formerly provided by a flow developer and six men was now producing only one third of the previous rate of log movement. It was evident that the location of the west boom was contributing significantly to the problem.

Opinions differed as to the size and shape of the packed area along the west boom and to determine the extent of the area affected, a float survey was undertaken by the Commission. The chute was opened, floats were launched about 200 yd. upstream from the dam, and their course was recorded by two shore parties equipped with transits, who took simultaneous fixes, at regular intervals. The current patterns obtained are illustrated on Fig. 4 where the arrows are also vectors and therefore illustrate the changes in velocity of the floats, as well as their direction of motion. It was evident from this survey that at least two thirds of the width of the river was supplying water to the plant leaving only the remainder available for log driving. There was also evidence that a fairly clear cut line of demarcation could be drawn between the flow lines leading to the chute and headworks respectively. It appeared that relocating the west boom along this dividing line so as to parallel the stream lines should provide a partial solution to the problem.

The other points concerning the location of the chute, and the draw towards its entrance were also investigated. Three sluices were opened to observe conditions which had occurred previously, and been considered satisfactory, and it was found that 2500 c.f.s. was capable of affecting surface currents for a distance out from the dam of less than 50 ft. The flow towards the powerhouse predominated, and its velocity was actually double the surface velocity leading towards the sluices.

Therefore, with the chute entrance located at the end of the streamlines, so to speak it was considered that its location was satisfactory. Velocities measured over the underwater crib, which also extended 50 ft. from the dam, were approximately double those of the surface current leading to the powerhouse, and it was considered that this would create an adequate draw provided the logs could reach the crib. From purely hydraulic considerations therefore it appeared that the problem might be solved by merely moving the west boom to parallel the stream lines as mentioned above.

First Field Test

As a temporary measure the west boom was moved, to take up a position as shown on Fig. 5, and held in position by cables attached to the east shore about 25 ft. above the water. At first small groups of logs were released to check the alignment of the booms with the current and these proceeded through the system without difficulty. When the entire mass of wood consisting of at least 12,000 cords was released, the system jammed about 100 ft. from the chute entrance after perhaps five minutes operation, and continual assistance was required thereafter.

An increase in driving rate of approximately 25% over the previous arrangement was achieved by moving the booms, but the rate was still 50% less than that obtained when using the sluices. Although it was clear that the chute entrance was capable of swallowing all the logs which were able to reach the crib, there was still some question about its location.

Because of the narrow width of the headpond and particularly because of the currents shown on Fig. 4 it appeared that the chute entrance was properly located, and that the remaining problem could be solved by preventing the majority of the logs from dragging along the booms which inevitably reduces the rate of movement and leads to jamming. To verify this opinion and also to save time in the field it was decided to construct a 1:24 scale model of the affected area of the headpond.

Model Construction

The model accurately reproduced the main spillway structure and bulkhead section, the east shoreline for a distance of approximately 500 ft., the log chute entrance and transition, the submerged approach crib and the projecting point of rock adjacent to the log chute entrance. The powerhouse draw around this point was reproduced by means of three adjustable gate sluices. That portion of the forebay irrelevant to the problem was sealed off by means of a water-tight

Fig. 4.

CURRENT PATTERNS

treamline vane, the location of the vane being determined from the float survey. A system of adjustable vanes and baffles was provided at the upstream end of the model to direct and control the water.

Nearly one mile of birch dowelling produced 250 model cords when cut into pulpwood lengths which duplicated the estimated natural proportions of 40%—4 in. diameter, 40%—6 in. diameter and 20%—9 in. diameter. The logs were twice immersed in a 5% silicone solution and allowed to dry. This prevented rapid water logging and, rather unexpectedly, almost eliminated the adhesive effects of surface tension so that the model logs behaved very naturally indeed. Provision was made for collecting the logs as they entered the chute and by a time-volume process the rate of passage of the logs was ascertained.

Model Verification

Data available for verification of the model consisted mainly of surface flow lines and velocities obtained by means of the float survey. A rather unusual feature of the verification was that because of the partial nature of the model the required amount of water flowing through was not known. However, surface conditions only were critical and very close agreement between model and prototype was achieved by a rather lengthy process involving a number of variables. The forebay level, and hence the log chute flow was held constant while adjustments, as required, were made to the outflow, inflow, or the baffles and vanes at the inlet end.

With the model operating correctly, the booms were installed in the same pattern as had been tried in the field the previous year and a run of logs was started through. The first few logs reached the chute but when the main mass reached a point between the converging booms about 100 ft. from the chute entrance, a solid jam developed. The booms were distended and large quantities of pulpwood were forced underneath and escaped toward the powerhouse. This very satisfactory duplication of what had occurred in the prototype completed the verification of the model.

Model Test Program

Under the existing circumstances, no conceivable re-alignment of booms could be expected to materially improve the situation. Between converging booms the product of mean velocity and distance between booms taken at successive sections moving downstream should ideally have a steadily increasing value or at least remain constant, but this situation seldom exists. It is necessary, therefore, to accelerate and direct the surface water to facilitate the movement of the logs toward the chute entrance. The simplest means of accomplishing this usually involves some form of hydraulic jet propulsion and, of the numerous devices available, flow developers seemed most promising. The model was required to determine:

(1) The effectiveness of flow developers and if applicable;

(2) The number of flow developers required;

(3) The optimum placement of the developers;

(4) The ability of the log chute to pass pulpwood at the desired rate.

Model Flow Developers

Because a 25 hp. flow developer produces a jet which extends for a distance in excess of 500 ft. it was considered probable that the correct number of developers would be between two and four. No detailed drawings were available but the manufacturer's advertising literature contained enough basic information and rough sketches to enable four sufficiently accurate models to be built. The vital dimensions and information about hydraulic performance were either available or could be deduced.

Fig. 6 shows two views of a model of a 25 hp. developer. The propeller shroud, a brass turning just slightly over one inch inside diameter contained four radial straightening vanes which supported the propeller shaft journal. A 1 in., three blade, stainless steel propeller operated within with a minimum of blade tip clearance. The shroud was rigidly attached to the motor box by brass tubular struts and the water inlet area was provided with a screen. The propeller shaft entered the motor box through a close fitting brass bearing which proved sufficiently water tight.

Originally an attempt was made to mount the drive motor within the box in the hope that the unit as a whole would be light enough to be self-floating like the prototype, but no motor could be found which was small enough and at the same time sufficiently powerful to provide the required torque. It was decided to use a heavier 115 v. a-c fan motor with a power input of approximately 45 w. and to suspend the whole unit at the proper submergence by a thin vertical wire, thus allowing a certain

Fig. 5. First field test with west boom moved as shown

this unless it proved to be essential.

As soon as the holding boom was released and the wood began to move the developers were started and the operation of the system was observed with no manual assistance being provided. After approximately half an hour of operation a small "island" of matted wood about 35 ft. in diameter came down and wedged between the booms about 30 ft. from the underwater crib. Two men were able to break up this mass sufficiently to allow it to reach the crib whereupon the hydraulic action provided by the chute proceeded to digest it without effort. This temporary blockage had been long enough to overfill the area between the developers and the chute and although operation continued at a very high rate it was evident that the system was not quite able to cope with the supply. Eventually a larger "island" came down which was over 50 ft. in width by 8 ft. in thickness and it effectively plugged the system. (Fig. 9)

It was evident from this test that wood was passing under the west boom between number one developer and its shore anchor point, and that this anchor point would have to be moved to the recommended location in spite of rock conditions. It was also clear that the flow developers were no longer operating satisfactorily although they had done so at the beginning of the test. The west boom was deepened to 30 in. between number one developer and the shore, the shore anchor point was moved, and the developers proved to be fouled by pieces of pulp-logs and bark which were removed.

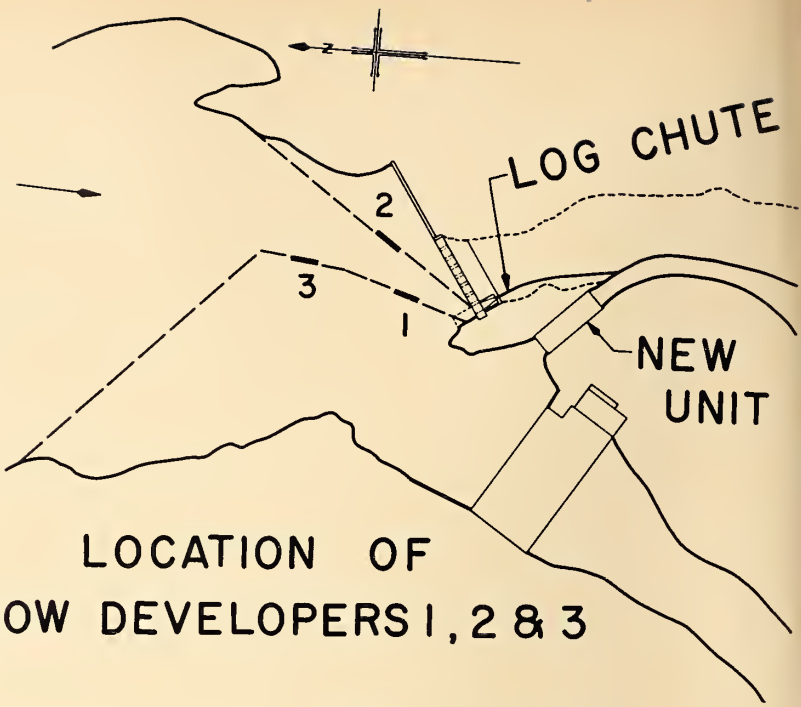


Fig. 8.

Final Tests

Once again the massed wood was released from the holding boom, and it was soon obvious that the problem had been solved. Even the matted "islands" managed to pass through unaided provided they were not more than 40 ft. wide. In due course one came down which was approximately 70 ft. wide but two men were able to ease it to the entrance without appreciably reducing the rate of log movement. After the first day of operation it was evident that the rate of log passage was at least equal to that obtained previously when using the sluices.

Fig. 9. "Island" of matted wood

Conclusion

One entire log-driving season has now been concluded using the flow developers. The water required for passing the logs through the structure has been reduced from 2500 to 700 c.f.s. Although the information on which the model tests were based was limited, the results obtained in the field were virtually identical to those obtained in the model. Considering the number of variables involved, the advantages of finding a solution to such a problem in a model are perhaps obvious. It is suggested that there are other similar problems which could be solved by the application of techniques similar to those mentioned in this paper.

Acknowledgements

The authors wish to thank the Abitibi Power and Paper company, and the members of its staff for their co-operation during the investigations; and in addition the many and varied contributions of the Cameron Falls staff were greatly appreciated.

EIC

FORCE VARIATION DURING THE FORMATION OF CONTINUOUS SEGMENTED CHIPS IN METAL CUTTING

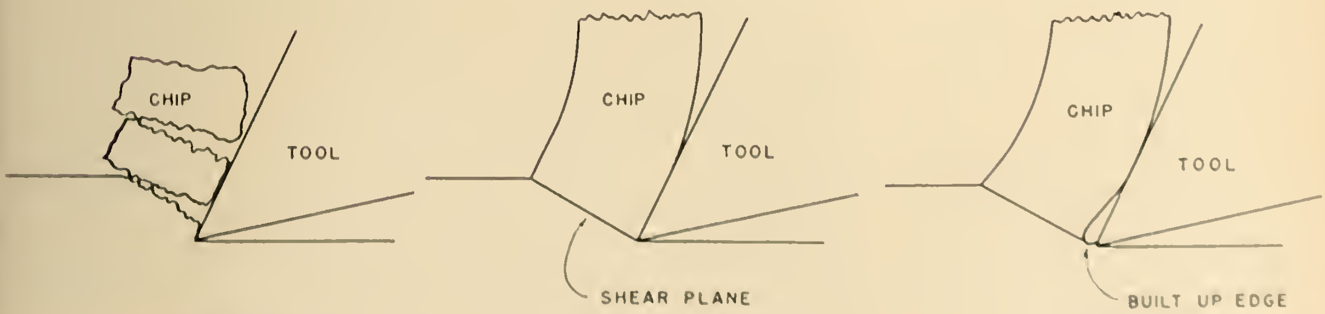
R. Salmon, A.M.E.I.C.,
Research Assistant, Department of Mechanical Engineering, Queen's University, Kingston, Ontario.

W. B. Rice, M.E.I.C.,
Associate Professor, Department of Mechanical Engineering, Queen's University, Kingston, Ontario.

L. T. Russell, M.E.I.C.,
Naval Research Establishment, Defence Research Board of Canada, Dartmouth, Nova Scotia.

A METAL CUTTING study usually has two objects, one direct, the other indirect. The direct object is to find out specifically what is involved in one or more of the components of the metal cutting process, such

Fig. 1. Ernst's Chip Classification (Schematic)



(a) Type 1 (b) Type 2 (c) Type 3

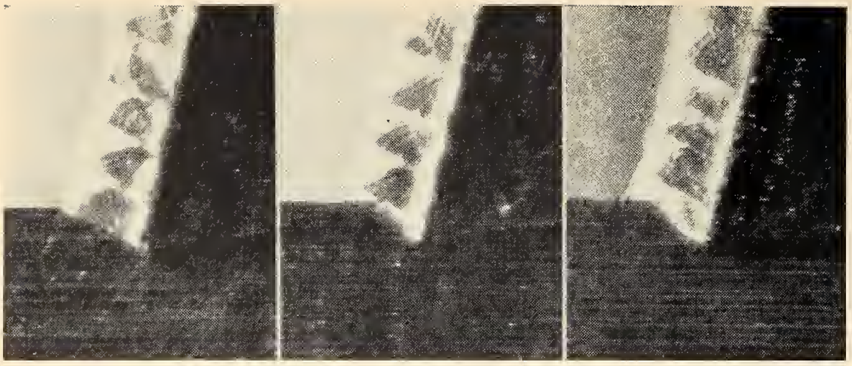
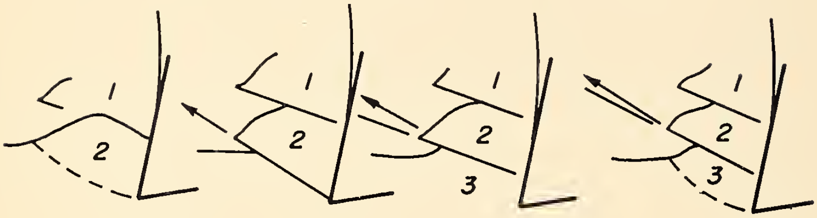


Fig. 2. Illustration of Segment Formation

Fig. 3. Schematic Illustration of Segment Formation



as tool geometry or friction. The indirect object is the application of the results to the improvement of specific manufacturing processes.

In manufacturing, the workpiece is the product, while the chip is merely discarded excess metal. In metal cutting research it may be advantageous to adopt the opposite point of view and consider the chip as the product and the workpiece as the residue, for in reality, the chip *is* the product of the metal cutting operation. In this way the need for studying chip formation can be appreciated.

Chip Classification

It has long been recognized that not all chips are formed in the same way, since different materials cut under different conditions yield different types of chips. In 1938 Ernst[1] classified chips into 3 types (Fig. 1) as follows:

The Type 1 chip is discontinuous, consisting of segments completely separated from each other. This type of chip is characteristic of brittle materials such as cast iron.

The Type 2 chip is continuous, characteristic of ductile materials, and is formed according to Ernst, by plastic flow on a shear plane extending from the tip of the tool to the free surface of the work ahead of the tool.

The Type 3 chip, like the type 2, is continuous and characteristic of ductile materials. It differs, however, in that a more or less stable deposit of workpiece material (called the built-up-edge) adheres to the tool tip during cutting.

Of these chip types the Type 2 *appears* to be most commonly encountered. Because it is the product of a uniform continuous process it is the most easily analysed; and most analyses of the mechanism of cutting assume that the chip is a Type 2, formed by a process of simple shear on a plane extending from the tool tip to the free surface of the workpiece. Unfortunately, predicted results are not always close to experimental results.[2]

Built-Up-Edge

The most obvious reason for the discrepancy is that under many cutting conditions the continuous chips produced are not, as is assumed, Type 2.

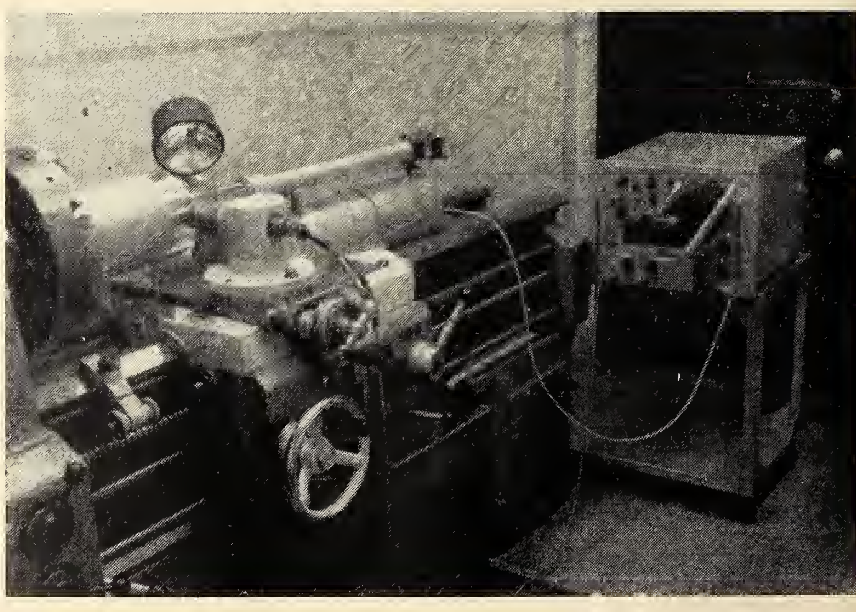
Earlier work at Queen's was based on the presence of small deposits of metal adhering to the tool when it was withdrawn from the work. This raised the suspicion that a built-up-edge existed over a much wider range of cutting conditions than hitherto supposed, and prompted a search for the built-up-edge in widely different cutting conditions.

Segmented Chip—a Periodic Process

The results of the investigation were surprising, but not concerned with built-up-edge. The chips although continuous, were neither Type 2 nor Type 3[3]. They consisted of segments firmly attached to one another. *The process of formation must therefore be periodic, not continuous.*

From numerous high speed photographs of the action, the steps in the formation of a single segment were determined, Fig. 2. At the beginning of a segment the material directly

Fig. 4. General Arrangement of Apparatus



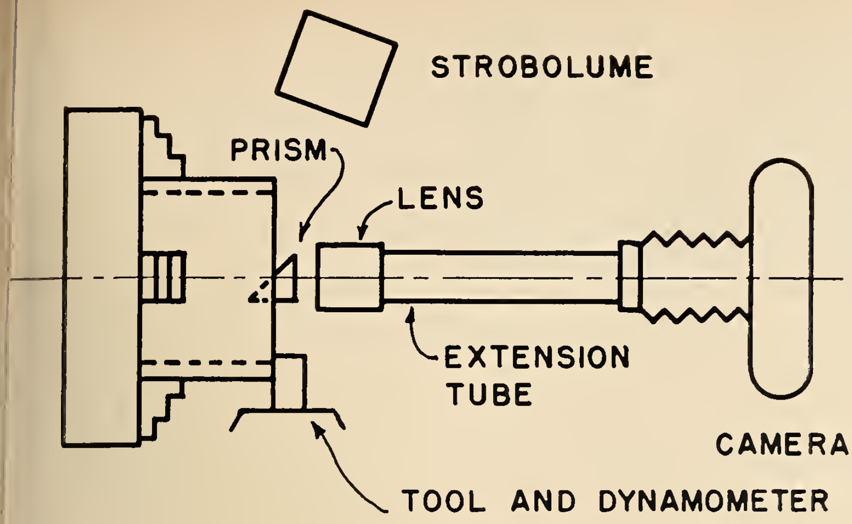


Fig. 5. Schematic Arrangement of Apparatus

n front of the tool is compressed, causing it to bulge upward. As the tool advances, further compression and bulging occur, forcing the previously formed segment up the tool face. Eventually as compression continues, rupture occurs, forming a new segment and completing the cycle. This is shown schematically in Fig. 3.

The mechanism of chip formation just described has been used to explain chip curl and cratering wear.[4]

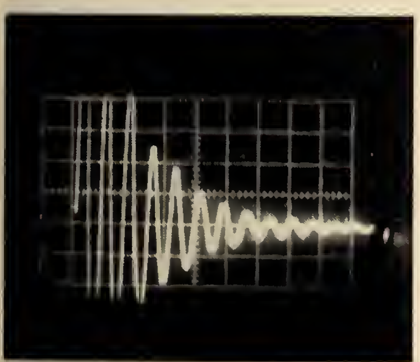
Purpose of Investigation

The existence of a continuous segmented chip poses a number of questions, answers to which are required for a better understanding of chip formation. The object of this investigation was to answer the following.

1. Does the cutting force variation parallel the segment formation?

2. How does the cutting force vary?

Fig. 6. Damped Vibration of Dynamometer Time scale: 1 division=2 milliseconds



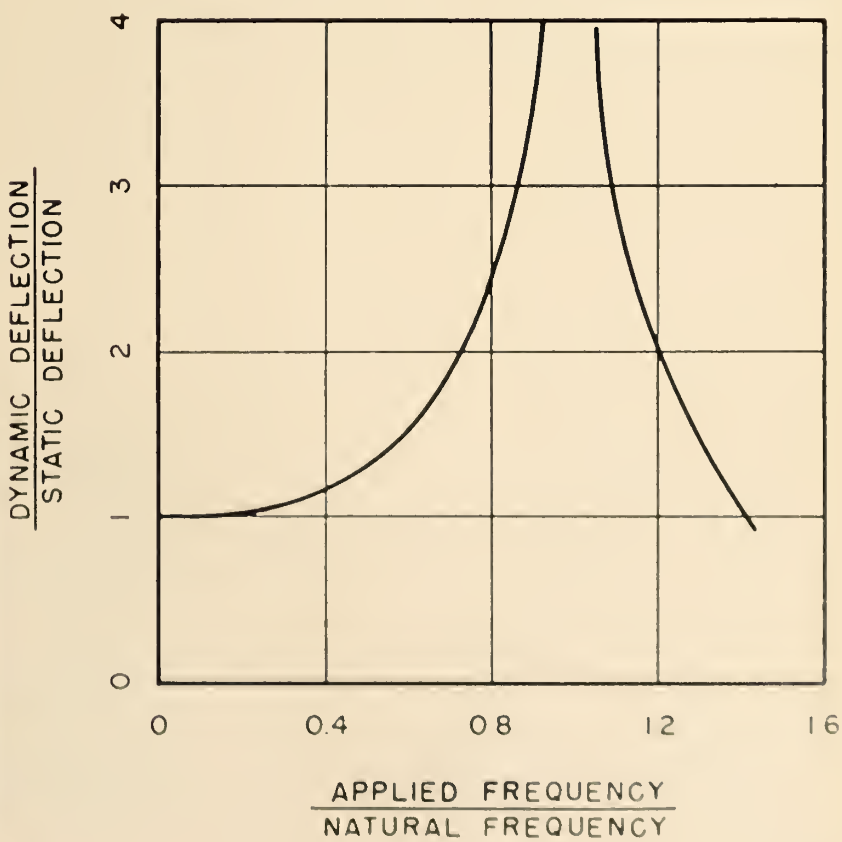
Apparatus

Basically the apparatus was the same as that described in a previous paper.[4] It is shown in Fig. 4 and schematically in Fig. 5. Tool force was measured by a dynamometer in the form of a tool holder, securely clamped cantilever fashion in a supporting block. Strain gauges, two on top and two on the bottom of the cantilever were connected together to form a full bridge for sensing the cutting force.

The chip was photographed through a prism by means of a camera and lens at the end of a long extension tube. The image formed at the camera was about five times actual size. The brief exposure was obtained by illuminating the chip with an intense flash lasting about 40 microseconds.

The natural damped frequency of the dynamometer was determined by striking the cantilever bar and displaying the strain gauge output on the cathode ray oscilloscope as shown in Fig. 6. The damping coefficient was also found in this way. The natural damped frequency was 665 cycles per second. The spring constant was found by calculating the deflection of the bar for a given load. From these data the response curve of the dynamometer was computed, Fig. 7. Thus the dynamometer should respond with an error of less than 8 per cent to a force cycling 150 times per second.

Fig. 7. Dynamometer Response Curve



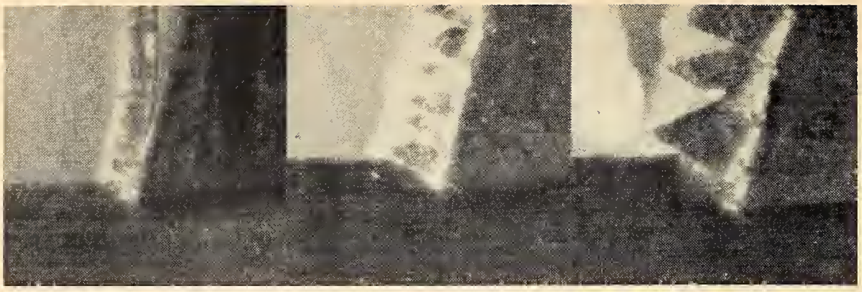


Fig. 8. Effect of Cutting Depth on Chip Formation. V=82 fpm, rake angle=15° (a) depth of cut 0.0088″ (b) depth of cut 0.018″ (c) depth of cut 0.033″

In order to limit the segments to 150 per second it was necessary to take a very heavy cut, 0.033 in. deep. At this depth, however, the chips obtained were quite similar to those produced by lighter cuts, except that segments were formed more slowly. The effect of cutting depth is shown in Fig. 8. The workpiece was 26S aluminum cut at 52.8 f.p.m. using H.S.S. tools with a 15° rake angle.

Originally a direct writing oscillograph was used to record cutting forces. This was unsuitable at frequencies above 100 cycles per second. Consequently a cathode-ray oscilloscope, equipped with a 25 kilocycle carrier preamplifier to energize the bridge, was selected to replace the oscillograph. The oscilloscope was equipped with a single sweep lock-out, which was advantageous for photography. The sweep was triggered using an induction coil of a few turns of wire around the high tension lead of the flash lamp. As shown in Fig. 9 the triggering voltage rise was very rapid, introducing a negligible lag between initiation of the flash and triggering the oscilloscope sweep. Thus the chip photograph corresponds with the beginning of the force trace, Fig. 10. This is one disadvantage, that the remainder of the force trace is for segments formed after the photograph was taken.

Results

Corresponding chip photographs and force traces are shown in Fig. 10. The time between force peaks is between 6 and 7 milliseconds. At 150 segments per second the average period between segments is 6.7 milliseconds.

A comparison of chip photographs and force traces discloses that when a segment is almost complete the force is almost a maximum and when a segment has just begun to form the force is near a minimum. The *usual* difference between minimum and maximum was 60 to 90 lb. The average total force under the same cutting conditions (previously measured with the oscillograph) was 545 lb. Thus the cutting force variation represents some 10 to 15 per cent of the average force.

Conclusions

1. The tool force variation is in phase with segment formation.

2. The tool force increases as the segment forms, falling off rapidly as the segment is completed, as expected from the proposed mechanism of continuous segmented chip formation.

Acknowledgements

The authors gratefully acknowledge the support of the Defence Research Board of Canada. They also wish to thank the Aluminum Company of Canada for donation of the material, and colleagues in the Department of Mechanical Engineering at Queen's University for their assistance.

The research upon which this paper is based is supported (in part) by the Defence Research Board of Canada, under Grant DRB 9535-03.

References

1. H. Ernst, **Physics of Metal Cutting**, Cincinnati Milling Machine Company, 1938.
2. D. Gideon, R. Simon, and H. Grover, **The Mechanism of Chip Formation**, Metal Cutting Research Reports. ASTME, vol. 1 Aug. 1, 1960, Report No. 9.
3. R. Salmon, **Chip Formation and Tool Chip Friction in Metal Cutting**, M.Sc. Thesis, Queen's University, 1959.
4. W. B. Rice, **The Formation of Continuous Chips in Metal Cutting**, The Engineering Journal, vol. 44, No. 2, Feb. 1961.

Fig. 9. Time Lag in Sweep Trigger Voltage

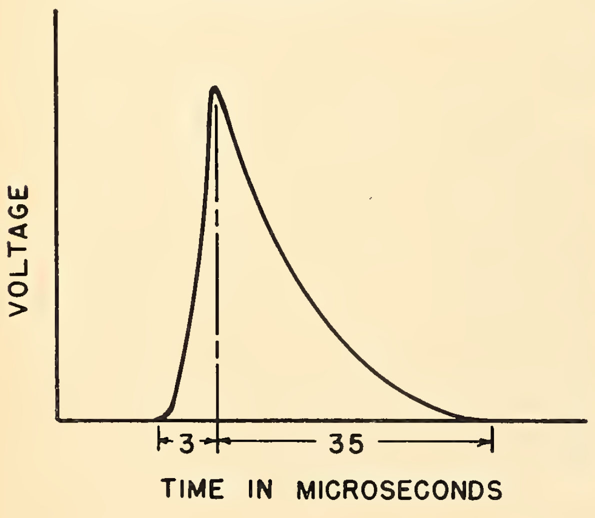
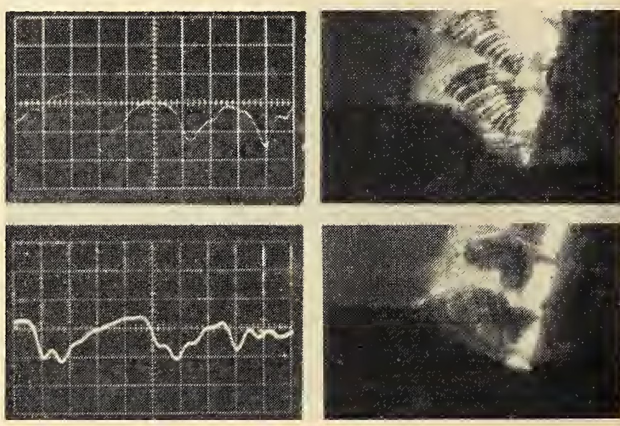


Fig. 10. Corresponding Force Traces and Chip Photographs. Scales: vertical, 1 division=40 lb; horizontal, 1 division=2 milliseconds.



CURRENT C.S.A. SPECIFICATIONS ON ENGINEERING DESIGN IN TIMBER

J. W. Wynand

Chief Engineer, Timber Preserves Limited, New Westminster, B.C.

CSA Standards in the timber field are kept up to date through continuous review by CSA committee members who are technical leaders in the industry. These committees also work closely with lumber associations in Canada and throughout the world.

DURING recent years, considerable improvement in design procedure and construction practice, based on intensified research and recognized engineering principles, have been achieved in the timber construction field. This development was not restricted to sawn timber construction only, but included manufactured timber products, such as glued-laminated timber and structural building components made of plywood, as well as foundation piling, wood preservation, timber fastenings and adhesives. In due course these developments had to be included in pertinent specifications of the Canadian Standards Association, either by way of revising existing editions, or creating new specifications, so that engineers, architects, manufacturers and contractors could refer to up-to-date timber specifications of recognized authority.

In realization of the importance of the National Building Code of Canada as a document more and more adopted in part or as a whole by cities, counties and municipalities throughout Canada, close co-operation between the committees of the Canadian Standards Association and the corresponding National Building Code groups during the preparation of the specifications was mandatory. Both groups realized that one standard for wood construction and one only should be in existence in Canada. The result of this co-operation is that the content of the section on Wood Design of the 1960 edition of the National Building Code of Canada is exactly the same as the Code of Recommended Practice for Engineering Design in Timber, published first in 1959 by the Canadian Standards Association.

CSA O86—1959, Code of Recommended Practice for Engineering Design in Timber

This is essentially a design code, providing information for the structural engineer on design criteria, formulas, working stresses and limitations, for the design of all kinds of structures using wood or wood products. It includes general design requirements applying to all wood products, as well as specific requirements for sawn lumber, glued-laminated timber, plywood, piling and fastenings.

Work on this code was begun early in 1955, and the first edition was published in the fall of 1959. The need for such a code had arisen as a result of work done in preparation for the 1953 edition of the National Building Code of Canada (referred to in the following as NBC) which was

issued early in 1955. Thus, complete information on timber construction for bridges and other structures as well as buildings would be available in documentary form from the Canadian Standards Association, both in regard to material specifications as well as to design practice.

The original idea was to provide a document which was essentially parallel to the National Design Specification for Stress-Grade Lumber and its Fastenings, published by the National Lumber Manufacturers Association in the United States (referred to in the following as NDS). However, as work on this new code progressed, it was found desirable to increase the scope by including plywood design and timber foundation piling, and to deviate from quite a few American procedures or principles, for various reasons. The purpose of this paper is essentially to discuss changes of CSA specifications and reasons for changes, rather than giving a complete description of content of each. Since CSA O86 code 1959 is a first edition, comparisons with previous procedures or principles can only be made with reference to previous CSA material specifications, NBC 1953 and NDS. In the following the major changes are discussed paragraph by paragraph as they are referred to in the new code.

Section 1: General Design

Para 1.3.3, Conditions of use. This paragraph is new and ties together the allowable working stress values and modifications with realistic design loads, normal quality of wood products, consideration of service conditions, adequacy of design, fabrication, grading and maintenance of the structure, and, finally with the proper use of wood products as graded for a designated end use. This provision not only reminds the designer of the many factors influencing the strength of a structural component, but also serves as a binding clause for convenient inclusion in construction contracts.

Para 1.3.4, Service Conditions. A new approach to service grades of glulam in this clause, refers to "exterior" and "interior" grades, the same terms as are used for plywood. Interior grades may be used where the equilibrium moisture content in service will average 15% or less over any year; exterior grade is to be used for all other service conditions. This not only defines quite clearly the limitation of use of interior grade, but also simplified the writing of design specifications by omitting the necessity of specifying the type of glue to be used. Since there are several glues available for exterior as well as for interior use, the new terminology has real merit.

Para 1.4, Grouping of Species. A rather outstanding change has been made in regard to tabulation of working stresses. Heretofore Canadian as well as American specifications listed working stresses for each species and of course for various grades, so that the designer was faced with selecting from more than 20 species and up to 17 grades for some of the species. To encourage good use of timber by keeping the design regulations as simple as possible, a system of grouping was worked out in which the species most widely used for structural purposes were left as individual species or put into very small groups, while species that were less commonly used structurally were grouped into larger groups. Naturally the properties assigned to the group as a whole were the controlling properties for the various species included in the group, and therefore provided an additional variable factor of safety for all properties except one property of one species.

It was found possible to combine all strueturally used species into four groups, without penalizing any one of the species unduly. Group 1, containing only three species, was further sub-divided into three subgroups: I (a), Douglas fir (dense), I (b) Douglas fir (non-dense), western larch and I (c) Pacific coast hemlock, in order to offer most economical use of these very important species. In this connection it is worthwhile to note that no longer is any differentiation of strength made between Coast Region Douglas fir and Mountain (or Interior, or Inland Empire) Douglas fir. The grouping system is applied not only to the tabulation of sawn timber working stresses but to that of glulam working stresses and permissible loads for timber fastenings as well.

Para 1.5.2.2, Duration of Loading. The fact that timber has the ability to sustain for short periods of time loads substantially in excess of those it will sustain for long periods without a loss in factor of safety, has been verified by tests for well over 20 years and considered in United States design specifications for about the same time. In Canada, modification factors for various durations of loading were included for the first time in 1953 in CSA specification O43, Structural Timber, and in CSA Specification O122, Glued-Laminated Timber Construction. At that time, working stresses were tabulated for continuous duration of loading and consequently percentages of these tabulated stress values for other durations of loading were calculated with reference to continuous duration as 100%. The types of short term loadings were: three years, two months, seven days, wind or earthquake, and impact. By number, magnitude and terminology, these modifications were essentially identical with those specified in NDS. In NDS, however, working stresses were tabulated for normal duration of loading. This is described in NDS as follows: "Normal load duration contemplates fully stressing the member to the allowable stress by the application of the full maximum normal design load for a duration of approximately 10 years (either continuously or cumulatively) and/or the application of 90% of this full maximum normal load continuously throughout the remainder of the life of the structure, without encroaching on the factor of safety". Since normal durations of loading are much more frequent than continuous load durations, the more realistic American approach was adopted in principle for CSA O86. A copy of the table of modifications for various durations of loading is given in table 1.

TABLE 1

Allowable Working Stresses for Various Durations of Loading

Duration of Loading	*Allowable Unit Stress—Percent*
Continuous	90
Normal	100
Two months	115
Seven days	125
Wind and earthquake	133
Instantaneous or impact	200

In conjunction with the table of modifications CSA O86 contains explanatory notes giving examples for the various load durations.

The 1953 edition of NBC provided only one factor for increase of allowable unit stresses which were tabulated for continuous loading: a factor of 1.33, by which tabulated stresses could be increased for concrete formwork, temporary trestles and other like temporary structures, and for wind and earthquake. After considerable investigation of the behaviour of wood under various conditions of loading, and in co-operation with the CSA working committees, which in turn supplied supporting data from the Forest Products Laboratories of Canada, full acceptance of the proposed modification factors by the NBC committees was finally achieved, so that CSA code O86 could be adopted in its entirety for the 1960 edition of NBC.

Section 2: Sawn Lumber

Para 2.2.2.1, Structurally Graded Lumber. Identification of structurally graded lumber by grade marking or certificate of inspection by an inspection agency has been introduced, as a desirable added requirement.

Para 2.3 Allowable Unit Stresses. As mentioned previously, the various Canadian species commonly used in construction have been grouped and working stresses are tabulated in Table 6 for normal duration of loading. Unfortunately, in 1960 Table 6 became obsolete in regard to Group 1 species, i.e. Douglas fir and Pacific coast hemlock with the publication of the 1959 Grading Rules of the British Columbia Manufacturers Association (referred to in the following as BCLMA), and a revision has been prepared. A great volume of the timber manufactured by member mills of the Association is exported to the United States; hence the sawmills had to manufacture to Canadian grading specifications as well as to American specifications, which caused obvious problems of many kinds. The Association therefore decided to adopt in full the American grading rules and working stresses as tabulated in NDS. The 1959 BCLMA Grading Rules refer only to the principal stresses of the various structural items graded for a specific end use, and the current revision of CSA O86 requires that they be so used. For example bending stresses are listed for joists, planks, beams and stringers, whereas compression stresses parallel to the grain would be listed for posts and timbers.

As Douglas fir and Pacific coast hemlock are species most widely used, a few more words should be said in regard to the latest changes of grades and grade names. In the Douglas fir section of BCLMA Grading Rule 1956, "select structural" and "structural" grades were listed. Also, two other stress grades were available: "dense select structural" and "dense structural". All other grades were non-stress grades and described as "select merchantable", "construction", "standard", "Utility" and "economy". According to paragraph 2.2.2.2 and 2.3.2 of CSA O86, working stresses could also be assigned to "construction" grade and "standard" grade for a specific end use, provided that the material was either used in load sharing systems, or singly when reselected for specified minimum slope of grain. In the Pacific coast hemlock section, the same non-stress grades as for Douglas fir were listed, but no stress grades included.

In contrast, BCLMA Grading Rule 1959 contains five stress grades for Douglas fir: "Dense Select Structural", "Select Structural", "Dense Construction", "Construction" and "Standard", and three stress grades for Pacific Coast Hemlock: "Select Structural", "Construction" and "Standard".

The most significant changes as compared to the previous Rule are as follows:

1. The term "Structural" grade is eliminated;
2. "Construction" grade, takes generally the place of the former "Structural" grade, and carries assigned working stresses;
3. A lower stress grade, "Standard", with an assigned working stress, is now available in both species, in the "joist and plank" category only.

Section 3: Glued Laminated Timber. Before the establishment of CSA O86, the design procedure for glued-laminated timber (in the following referred to as glulam) was described in the 1953 edition of CSA Specification for Glued-Laminated Timber Construction. The procedure recommended therein was felt to be not only very cumbersome and impractical for use by engineers and architects, but also caused a great deal of misunderstanding and misuse, which in fact did a good deal of harm to the laminating industry.

In regard to the consideration of imperfections, such as knots, in design, this procedure provided for three methods of knot restriction. Method 1 required no control of knot placement in adjacent laminations, and for design the maximum knot was assumed at the critical section in every lamination. Method 2 required control in manufacturing to the extent that maximum knots in adjacent laminations were no closer longitudinally than the width of the lamination, and for design assumed the maximum knot in the outer laminations at the critical section with a maximum knot in each alternate lamination therefrom, and no knots in the intermediate laminations. Method 3 restricted the total number of maximum knots in the member, requiring again control of knot location during manufacture. The result of this approach was more than discouraging: Designers would often decide for method 1 with no control required, for simplicity of calculation of net effective moment of inertia, also sometimes questioning whether or not the manufacturer adhered strictly to such controls; manufacturers were forced to increase the cost of glulam manufactured under methods 2 or 3 owing to the rigid and expensive controls required. The savings achieved in design by obtaining smaller size members were thus often exceeded by the extra cost of control. Hence method 1 was mostly used, which was in fact too conservative, and raised the cost of glulam construction unnecessarily.

To complete the picture of confusion, it should be mentioned that engineers often got to the point of desperation and fell back upon specifying glulam in accordance with the American NDS. Since the latter specification lists grade combinations based on grades used in the sawn timber industry, whereas Canadian laminating manufacturers would grade their stock to laminating grades A, B, C and D in accordance with CSA O122, none of which is identical with sawn timber grades, one can easily imagine the waste of time and energy, let alone complications, arguments and annoyances that arose from most such instances.

The reason for preferring the American procedure was simply because it would provide the engineer with working stresses directly assigned to one specific grade combination, ready for use in design as for solid sawn timber without onerous calculations. When considering a major revision of the Canadian procedures, it was realized that the American approach would still leave the decisions to the design engineer as to which of the many grade combinations providing the same working stress should be used in manufacture. This was considered to be poor economy, since the designer could not be expected to know what proportions of which laminating grades would be most advantageous, from the point of view of supply of stock, location of plant and other practical factors.

It was therefore decided to separate design procedure and working stresses from production requirements and grade combinations completely, by including the former in CSA O86: Code of Recommneded Practice for Engineering Design in Timber, and the latter only in a revised edition of CSA O122, now called Specification for Glued-Laminated Softwood Structural Timber, set up as a material specification to deal only with requirements for raw materials and the manufacture of glulam.

The first step in the new direction was to decide upon the stress levels for which working stresses for use in glulam design would be published. The CSA specification committee, in close co-operation with the engineers of the members of the Fabricating Division of the Canadian Institute of Timber Construction, finally agreed on the following strength grades

1. 24f, selected to be most efficient for members stressed principally in bending;

2. 20c, most efficient for members to be stressed principally in compression, and where short-column strength would govern, rather than buckling;

3. 18c, most efficient for members to be stressed principally in compression, and where column buckling would govern;

4. 26t, most efficient for members principally stressed in tension parallel to grain, as in truss chords.

Working stresses would be calculated for all types of stress in each strength grade, but the name of the grade itself indicated the strength in the most efficient property for dry conditions of use at normal duration of load. For example 24f stress grade would have an allowable unit stress of 2400 p.s.i. in dry conditions of use at normal duration, but only 1900 p.s.i. under wet conditions, or 1600 p.s.i. in compression parallel. The number of stress grades was kept to a minimum to promote efficiency, avoid confusion, and achieve simplicity.

Various grade combinations were then worked out that would provide the strengths required; these were tabulated in the new CSA O122 specification. The procedure used in deriving at the new grade combinations was based on a knot frequency study and will be discussed in more detail in the section dealing with that specification.

Table 8 of CSA O86 lists all working stresses for the four stress grades of glued-laminated Douglas fir at normal duration of load, both for dry and wet service conditions. Following the new concept of species grouping, Table 9 lists modification factors for allowable unit stress for species groups, to be used in conjunction with the values listed in Table 8, when species other than Douglas fir are selected.

Inspection of Table 2, an extract from Table 8 of CSA O86 shows what is meant by "most efficient use". The grade combinations permitted for 24f stress grade are selected to give greatest strength in bending, and thus only 2000 p.s.i. is allowed in tension. On the other hand, the strength of 26t is 2600 p.s.i. in tension but only 2200 p.s.i. in bending.

This new design procedure has now been in use for a year and a half, and has proved successful with both the engineering profession and glulam manufacturers.

TABLE 2

Allowable unit stresses for Stress Grades of Glued-Laminated Douglas fir, Normal Duration of Load, Dry Service Conditions

Stress Grade Number	*Extreme fibre in bending, p.s.i.*	*Compression parallel to grain, p.s.i.*	*Tension parallel to grain, p.s.i.*
24f	2400	1600	2000
20c	2400	2000	2400
18c	1600	1800	2300
26t	2200	1900	2600

Section 4: Plywood. The allowable unit stresses for Douglas fir plywood under dry service conditions presently shown in table 10 for normal duration of loading are similar to those recommended by the Plywood Manufacturers Association of British Columbia and by the Douglas Fir Plywood Association, Tacoma, Washington, for permanent duration of loading. This was decided upon because studies on plywood working stresses conducted jointly by the U.S. Forest Products Laboratory and the Douglas Fir Plywood Association were still under way at the time of preparation of C.S.A. Code O86. These studies have now been completed and the results of the tests which were carried out and the recommendations made by the U.S. Forest Products Laboratory have been endorsed by the Forest Products Laboratory of Canada, and accepted by the CSA Committee on Engineering Design in Timber. Consequently a revision has been made to table 10 of CSA Code O86, which gives working stresses for Douglas Fir Plywood, making these changes:

1. Increase of "shear through thickness" (shear in a plane perpendicular to the plies) by approximately 25%.

2. Increase of all stresses except modulus of elasticity by 10/9ths to convert to normal loading.

These revisions have also been incorporated in the 1960 edition of NBC.

Section 5: Timber Piling. In line with all other sections of this specification, this section deals with design considerations only and does not include any material specifications. The design provisions included are based on accepted principles of engineering as referred to in a number of textbooks on this subject.

Because piling is so dependent on the bearing capacity of the soil, the design strength of the pile is rather of secondary importance. However, CSA Specification A 56 for Round Timber Piles provides for certain minimum requirements of quality which in turn permit the use of structural grade timber stresses as listed in clause 2.3.1. of this specification, in the structural design of timber pile foundations. It may be of interest to mention in this connection that on the basis of equal quality, round piling is stronger than sawn timber, because the wood fibres of a pile are less disturbed than in a sawn timber.

Section 6: Timber Fastenings. The section on timber fastenings is comparable in content and approach with the same sections in NBC 1953 and NDS. Changes in comparison with NBC 1953 include the revision of load values and certain conversion factors, due to rearrangement of the grouping of species and conversion from permanent duration of loading to normal duration, for reasons outlined before. A rather important new provision is contained in paragraph 6.3.1.7.2., saying that "for glued-laminated timber, the tension or compression stress in the net section shall not exceed the allowable unit stress in compression for the stress grade used".

CSA O122—1959, Specification for Glued-Laminated Softwood Structural Timber

The preface to this second edition states: "The second edition of this specification supersedes the first edition issued in 1953 under the title Glued-Laminated Timber Construction. Unlike the first edition, the second edition has been limited to deal only with the material and assembly techniques required for the production of glued-laminated softwood structural timber, as the information on design and working stresses for glued-laminated timber is now incorporated in the CSA Code O86, Recommended Practice for Engineering Design in Timber."

Since the second edition is markedly changed from the first edition, the major changes are again discussed paragraph by paragraph as they are referred to in the revised specification.

Paragraph 3, Classification. This paragraph classifies glulam according to stress grade, service grade and appearance grade, each of which is independent of the others. The requirements for service grades and stress grades are referred to throughout the specification, and those for appearance grades are described in detail in paragraph 5.10. This is of great help to engineers and architects in writing specifications. It should be emphasized that these three grades completely describe the material, and the job specification writer need not go into further details.

Paragraph 5, Manufacture. Table 9 incorporates the manufacturing requirements and gives laminating grade combinations and minimum scarf joint requirements for stress grades 24f, 20c, 18c and 26t, as referred to in CSA Specification O86. In establishing the number of grade combinations, the manufacturer was given adequate latitude of choice for most economical results. Since the working stresses were fixed regardless, of the the number of laminations, the laminating grades used could become lower as the number of laminations increased.

In contrast, the American approach, as incorporated in NDS, recommends particular combinations of stress grade laminations and increases the allowable working stresses with the increase of number of laminations, and thus with the member size.

All of these laminating grade combinations were derived by using the results of knot frequency studies carried out by the Canadian Institute of Timber Construction in close cooperation with the Forest Products Laboratories of Canada and the Pacific Lumber Inspection Bureau. The procedure of these studies followed that recommended by the U.S. Forest Products Laboratory in Madison, Wisconsin, using grades selected from laminating stock at two western plants and two eastern plants of Canada. This procedure is described in detail in Technical Bulletin 1069, published by the United States Department of Agriculture.

Parallel to the knot frequency studies, extensive testing of various types of scarf joints of various slopes were carried out at the University of Toronto, the University of Alberta and the Forest Products Laboratory in Ottawa, all of which supplemented that done by the Forest Products Laboratory at Madison, Wisconsin. These Canadian tests revealed the importance of keeping the thickness of the tip of a scarf joint (dimension "A" in the sketch drawn on page 19 of the specification) to a minimum in order to obtain maximum overall strength of the joints. Consequently, tip step dimensions and hook dimensions are also limited in table 9.

Appendix A, Control of Manufacturing Quality. While as an appendix this is not a mandatory part of the specification, it points to the importance of careful control of quality throughout all stages of manufacture, and recommends one or more of these means of assessing quality:

(a) Grade-marking or other designation of quality, issued under the authority of a responsible trade association or similar authoritative body, attesting to quality of manufacture;

(b) Independent inspection of all or part of the manufacturing process, by the buyer or his agent;

(c) Tests of the product, by the buyer or his agent.

In connection with the responsible trade association referred to under (a), it should be mentioned that the Canadian Institute of Timber Construction operates an industry-wide quality control program which incorporates both product tests and regular inspection, as well as additional rigid requirements to assure regular adherence to specifications and maintenance of quality. The system is implemented by the Institutes "Qualification Code for Application to Manufacturers of Structural Glued-Laminated Timber", which is, in fact, a very necessary and desirable supplementary requirement to CSA specification O122. The Institute recommends that the following clause or its equivalent be incorporated in all construction specifications where structural glulam is employed: "Structural glulam shall be manufactured by a plant approved by the Canadian Institute of Timber Construction as a Certified Manufacturer for Class . . . work. The Certified Manufacturer shall provide a Certificate attesting to manufacture under the Institute's Qualification Code and shall affix the authorized label to all structural members supplied".

CSA O121—1957, Specification for Douglas Fir Plywood and Western Softwood Construction Plywood

This is the third edition and provides for new grades of plywood as follows:

1. High Density Overlaid Plywood;
2. Medium Density Overlaid Plywood;
3. Factory Grade;
4. Underlay Sheathing Grade.

Appendix A has also been revised to make it conform with requirements of Central Mortgage and Housing Corporation and the National Building Code. At the time of writing of this paper, a fourth edition is in preparation and will be published this year. Changes are not of a major nature and will provide for:

1. Use of plastic patching compound for minor repairs in "A" and "B" grade veneers;
2. Addition of a new concrete form grade;
3. Change of name of "Underlay Sheathing" to "Select Sheathing".

It should also be mentioned that two new specifications in the plywood series are in preparation. CSA O151 which covers Western Softwood plywood will be published this year. Another specification, CSA O152, entitled Specification on Performance of Construction Plywood, has been in preparation for five years, and it is hoped that a final draft will be available before the end of 1961. The object of this Specification is to provide performance criterias for plywood used in dwelling construction.

CSA A 56—1942, Standard Specifications for Round Timber Piles

A second edition is in preparation and scheduled for publication during this year. The forthcoming changes will result in simplification and clarification by separating the specifications for material and manufacture. Also there will be only one grade of piling, and the three classes of piling for various sizes of butt and tip will be eliminated. This change will avoid future misinterpretation of the specification, assuming that for example Class A piling would not only be larger in size but also of better quality than Class B or Class C piling, which of course was not the case. For the same reason, a table containing pile sizes will not be included in the new edition but a recommendation be made that piling shall be specified by minimum butt diameter and/or tip diameter, thus inviting the designer to restrict sizes to actual requirements. However, the appendix lists pile sizes commonly available in different species to avoid miswriting of specifications.

CSA O43—1953: Specification for Structural Timber

After the first edition (A43—1937) was published, some major changes were made, including increases of working stresses for certain properties and duration of load modifications and incorporated in a revised version, O43—1953.

With the publication of CSA O86—1959, Code of recommended Practice

of Engineering Design in Timber, working stresses and other design information given in this specification and its appendices became superfluous, and were deleted by amendment, leaving those parts pertaining to the specification of materials. The publication of B.C.M.L.A. Grading Rules 1959 called for changes of some grade names and grade requirements, and it was then decided to strike out all specific references to Douglas Fir and to leave CSA O43 as a general material specification for sawn lumber of all species except Douglas Fir. These changes have now been made by an additional amendment, so that CSA O43 is now a general material specification for stress-graded lumber not otherwise covered by regional grading rules.

CSA O112 Series: Specifications for Wood Adhesives

The reason for the development of this series was not only the need for a reference in manufacturing specifications of glued-laminated timber, plywood and other materials, but also because it became rather awkward to have to refer to American specifications in National Defence contracts. A complete series including all adhesives was planned but only those of greatest interest from the point of view of woodworking use have been completed in 1960. These include animal glues, starch glues, casein glues, polyvinyl adhesives, urea resin adhesives for room and high-temperature setting and phenol and resorcinol resin adhesives for room and intermediate - temperature setting. Specifications for which there is less immediate need, covering adhesives, will be prepared in due course.

The specifications available to date outline the requirements for the materials themselves, in regard to physical characteristics as well as to their performance under certain specified tests. The test procedures are grouped in one specification which is referred to by all of the other specifications, since the test procedures are basically the same for all. Since the quality of a glue line or a glued joint depends not only on the quality of the adhesive itself, but also on proper application, the development of a companion series on the application of adhesives under series number O113 is planned.

CSA O80—1959, Specification for Wood Preservation

The first edition of this specification, CSA O80 series, 1954, was almost in complete agreement with the Manual of Recommended Practice of the American Wood Preservers Association (in the following referred to as AWPA Manual), except that it was published in the standard CSA format. Since it was very difficult to keep up with changes in AWPA Manual, the CSA Committee on this specification decided to discontinue this series and to adopt the various specifications of the AWPA Manual by reference. The 1959 edition of CSA specification O80 is published in such a format that it can be inserted in the front of the standard AWPA Manual ring binder. It consists of adoption of the current AWPA standards by reference with such additions or deviations as are considered necessary in order to provide for Canadian species and service conditions in regard to requirements of preservative retentions. With regard to the latter it should be pointed out that some of the AWPA specifications are under revision and it is quite possible that both American and Canadian specifications will be in agreement after these revisions have been carried out.

For most purposes, the CSA Specification on Wood Preservation must be considered a supplement to the AWPA Manual, since the latter is needed for a complete reference on any preservative, method or commodity.

Conclusion

In closing, may I point out that CSA Standards in the timber field are kept up to date through continuous review by CSA committee members, who are technical leaders in the industry. The CSA committees co-operate closely with regional lumber associations in Canada, and keep in touch with related groups in other countries throughout the world.

CSA Specifications are amended by the addition of gummed amendment slips, automatically sent to those who return a form request for them included with each copy of a specification. Failure to keep up to date by inserting amendments accounts for many incongrous job specifications.

CSA Specifications are available from the Canadian Standards Association, 235 Montreal Road, Ottawa. CITC and AWPA codes and specifications are available from the Canadian Institute of Timber Construction, 140 Wellington Street, Ottawa.

Acknowledgements

Considering that so much work had to be done by so many organizations and individuals, during a period of at least seven years, acknowledgement should be made to those who dedicated a considerable portion of their time and energy to the common task, before describing and discussing in detail the changes and reasons for changes of the various C.S.A. specifications dealing with wood and wood products. To name all who contributed to this work would be unduly time-consuming, so I can mention only a few; the importance of the contributions of the many others who participated in committee meetings and wrote thoughtful comments has by no means been forgotten:

W. Thornber, field officer of the Forest Products Laboratories of Canada, who chaired the committee on Engineering Design in Timber and was responsible for co-ordinating the efforts of his committee members; *Selwyn P. Fox*, who carried out extensive tests on glued-laminated timber construction and co-ordinated the statistical studies that led to establishment of the present working stresses; *R. W. Peterson* of the Forest Products Laboratories of Canada who led the several committees that developed adhesive specifications; *D. E. Kennedy* of FPLC, who chaired committees on stress-grade sawn timber grading rules and manufacture of glulam; *R. L. Bonham*, who spearheaded the preparation of the first CSA standard on wood preservation; *J. C. Armstrong*, who headed up the preparation of plywood material and design specification; *C. D. Carruthers* and *D. C. MacCallum*, who, through their work on the Advisory Structural Group of the National Building Code, cleared up doubtful points on load duration and further refined design requirements generally; *Col. J. H. Jenkins*, Chairman of the CSA Sectional Committee on Timber, and *R. F. Legget*, Chairman of the Associate Committee on the National Building Code, who made arrangements to assure that we had only one Canadian standard for Timber Design; and many others.

Not to be forgotten, too, are the many associations who contributed services of their staffs and members; among them are:

The Forest Products Laboratories of Canada, Ottawa and Vancouver;* The Division of Building Research of the National Research Council, Ottawa; The British Columbia Lumber Manufacturers Association, Vancouver; The Canadian Lumbermen's Association, Ottawa; The Plywood Manufacturers Association of B.C., Vancouver; The Pacific Lumber Inspection Bureau, Vancouver; The Canadian Institute of Timber Construction, Ottawa and Vancouver; and many others.

*The name of the Forest Products Laboratories of Canada has been changed to Forest Products Research Branch, Department of Forestry, as of March 1961.

To Mr. E.I.C.

Member and Associate Member

IF ONLY our budget would have permitted it you would have received this personal letter in your mail because its message is of the highest importance to an engineer of your standing.

YOU WERE advised recently that Council prepared a motion to revise the by-laws. This revision would increase the membership fee to a more realistic level so that current expenses of administration can be met and an improvement of service made possible. You will be asked to vote in a ballot to be mailed to you during the summer months.

The proposed schedule of fees is:

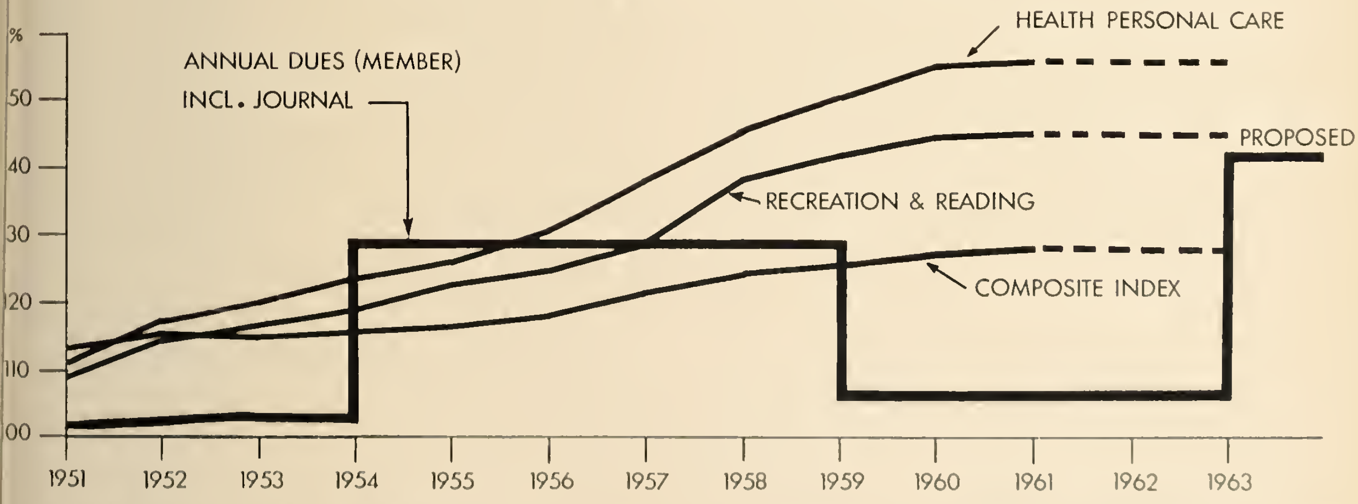
Fellows and Members	**$24.00**	**Students**	**$ 3.00**
Associate Members	**14.00**	**Affiliates**	**25.00**

BRANCH non-residents and non-residents will pay $2.00 less. This will not apply to students whose fees will remain at $3.00.

NO ONE looks with great eagerness to increased fees in Learned Societies, Technical Institutes or any other club or group. On the other hand you no doubt wish your Institute to at least retain its present effectiveness and would like it to be of greater service to the community.

YOU WILL admit that costs of operating any organization have increased. The following graph, drawn from information published by the Dominion Bureau of Statistics, indicates that the proposed increase is not incommensurate with general cost of living increases.

TOTAL ANNUAL MEMBER DUES[1] VS. DBS INDICES[2]

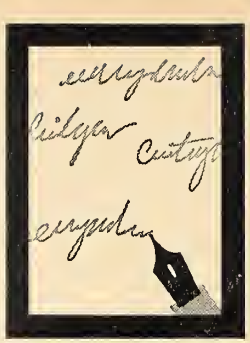


1. Includes fee for Journal. 1951 equals $17.00.
2. Includes Food, Housing, Clothing, Transportation, Recreation and Reading, Health and Personal Care, Tobacco and Alcohol.

WHEN YOU receive your ballot next summer, keep this chart in mind; the request for an increase is not out of line.

G. N. Martin, M.E.I.C.,
Chairman, Finance Committee

Abstracts



Papers to be presented at the 1962 EIC Annual General Meeting

Following are the abstracts received by press time. Abstracts of other papers to be presented at the 1962 Annual General Meeting will appear in the June issue of the Engineering Journal.

AGM Paper No. 8

Construction Features of the Place Ville Marie Project

T. M. Phelan, Project Manager, Foundation Company of Canada, Montreal

This paper describes the general construction features of the Place Ville Marie Project. It outlines some of the preplanning of various temporary facilities carried out before commencing construction operations, as well as the most successful technique developed on the project for blasting and removing more than 125,000 cu. yd. of rock in downtown Montreal. The tie-back shoring method, which was also developed on this project is described, as are numerous other construction innovations and procedures involving many trades found to be effective in constructing a large high-rise structure.

AGM Paper No. 11

T.C.A. Overhaul and Maintenance Base

E. A. Dahl, Structural Engineer, Ross, Fish, Duchenes & Barrett

T.C.A. has recently put into operation its $20 million Jet Maintenance Base at Dorval, Que. The buildings alone cover 14 acres. Two of these buildings are hangars. One, a series of 175 ft. span cantilevers supported on a mast and anchor, is unique in the length of the cantilever; the other, a 90 ft. series of cantilevers suspended from the edge of 150 ft. span reinforced concrete rigid frame, is unique in its design. Both hangars are among the largest in existence. The paper will describe the structures as such, and deal with some of the unique problems of the design that were encountered, and their solution, in a descriptive fashion.

AGM Paper No. 13

The Pipeline Flow Characteristics of Crude Oils

G. W. Govier and R. A. Ritter, University of Alberta

Many crude oils discovered in Western Canada display unusual flow properties at the temperatures encountered during storage and pipeline transportation. Careful consideration of deviations from Newtonian behavior is essential to the accurate design of most flow systems associated with these liquids.

The characteristic behavior of Newtonian, pseudoplastic and time dependent or thixotropic crude oils is reviewed with particular attention given to the techniques involved in the measurement and interpretation of the rheological data. Several examples of each type are presented to demonstrate the rather wide variations which are possible within each of the three classifications.

Application of laboratory data to the design of crude oil pipelines is discussed. The complications arising from the shear rate dependence of pseudoplastic crude oils and the shear rate and time dependence of thixotropic crude oils is considered under both laminar and turbulent flow conditions.

AGM Paper No. 22

Soil Cement Construction in Alberta and Saskatchewan

E. B. Garret, M.E.I.C., *Development Engineer, Inland Cement Co. Ltd., Regina*

This paper will briefly describe the history and development of soil cement in the United States and Western Canada. Soil cement will be defined and some of its engineering properties given. Also the different uses of soil cement will be described along with its growth in Western Canada and United States during the last 27 years. The adaptability of soils to soil cement and the laboratory testing required to determine proper cement contents will be discussed. Examples of construction procedures used by Edmonton, Saskatoon and Alberta Department of Highways will be given. Methods of curing and bituminous surfaces will be described along with the basic fundamentals of inspection and field control. The paper will close by showing some of the factors effecting the costs of soil cement and discussing design criteria now being utilized.

AGM Paper No. 24

Magnetic Inverters
A Review of Switching Processes

C. H. R. Campling, M.E.I.C., *Queen's University, Kingston.*
J. A. Bennett, A.M.E.I.C., *Queen's University, Kingston.*
C. H. O'Hara, A.M.E.I.C., *National Research Council, Ottawa.*

Switching in single-phase inverters and transient locking phenomena in polyphase inverters are discussed. The class of inverters with which the paper deals includes those in which the operating frequency and (for polyphase inverters) the electrical angles between phases are determined by the characteristics of the inverter transformers. Polyphase units of this type are known as self-locking inverters.

Two circuit arrangements are presented which permit the generation of pure rectangular voltage waveforms at arbitrary voltage levels with self-locking inverters. In addition a simple method is demonstrated for generating output waveforms which are stepped approximations to sinusoids.

AGM Paper No. 27

Research in Britain on Current Ratings for Cables and Overhead Lines

E. E. Hutchings, The Electrical Research Association, Surrey, England

The basic current rating formula for solid-type cables is given and it is shown how account may be taken of the particular features of high-voltage cables of other types.

The thermal resistance external to the cable surface is dependent on environment. For buried cables this depends on the thermal resistivity of the soil, methods for determining which are described. Reference is made to a system of soil classification which has been developed for use by cable engineers. Details are given of investigations into seasonal variations and the onset of runaway conditions due

to drying of the soil by the cable. Some observations are made on the use of special back-fills and on the possible adoption of different ratings for summer and winter. For cables in ducts similar considerations apply but the external thermal resistance is more complex due to the air space within the duct-way and the danger of drying out is alleviated because of the lower temperatures which occur in the soil. The permissible temperature of such cables is moreover limited by thermal expansion effects and it is shown how these may be alleviated by attention to the layout of terminations. The thermal dissipation from the surface of cables run in air is shown to vary widely with the mode of installation. The parameters in the basic formula have been determined for some commonly used arrangements, but for cables in buildings and ships generally it has been necessary to adopt compromise ratings based on experimental results covering a range of conditions.

It is shown that plastic insulated cables, unlike other types, may sustain rapid damage from comparatively small overloads and that their ratings should therefore be related to the operating current of the fuse or circuit-breaker which protects them.

The effects of short-circuit currents on cables are described and criteria established for short-circuit ratings for certain types.

Thermal ratings for overhead line conductors and their significance are dealt with briefly and experimental work described.

AGM Paper No. 33

Mining Engineer Education

A. V. Corlett, Head, Mining Department, Queen's University, Kingston

A man may enter mining engineering through either a two-year course in a technical school, more particularly the Provincial Institute of Mining, from the equivalent of Grade 12 in Ontario, or a four-year course in a university after the equivalent of Grade 13 in Ontario. About one-third to one-half of the entrants enter by the technical school route. The two groups start off evenly for traditionally "the only way to learn about mining is on-the-job", and the technical school men who have worked on a narrower program are as skilled at the technician level as the young engineer, or more so. The young engineer's skills were learned in the lower years at university, as a small part of his training.

The university student has spent about 30% of his time on fundamental studies common to all engineers and 50% on cognate subjects, such as geology and metallurgy. Not much of his time was spent on strictly mining subjects.

A mining engineer must know more about the forces that he deals with in mine design than any other engineer knows about them, and they are more abstruse than those any other engineer has to deal with. He must know the value of his ore. He must design systems to co-ordinate the work of men and machines to move it. Those constitute the field that is mining engineering and all are based on data that have varying degrees of reliability. Mining engineering students are being educated to interpret those data. If industry does not recognize the utility and availability of that talent our efforts are wasted.

AGM Paper No. 35

The First Five Years of the Co-operative Engineering Programme at the University of Waterloo

Dr. D. T. Wright, Professor & Chairman of the Department of Civil Engineering & Dean of Engineering at the University of Waterloo, Ont.

The paper first sketches the history of the development of higher education in Waterloo, the background of early foundation of church-supported Arts colleges, the creation of the associate faculties and the inception of the co-operative engineering course.

Since the co-operative system is unique in Canada at Waterloo, some idea is given of the scope, scale and significance of co-operative education and its parallels in the U.S. and U.K. Particular attention is given to the Edison/Ford Foundations' study of co-operative education in the United States.

The organization of the co-operative programme at Waterloo is then described. The arrangement of terms, the three-month and four-month systems etc. are all described. The unique role of the Co-ordination Department in providing formal liaison between the University and industry is then discussed, along with other aspects of relations with industry. Some comparisons are made between practices in the U.S. and U.K. and those in Canada in respect of student-industry relations.

The development and evolution of undergraduate curricula are then discussed, with particular respect to changing aspects of engineering in society. Approaches to "design" education are also discussed.

The rise of postgraduate study and research in the University are touched upon briefly. Some discussion of professional graduate study in engineering is also given.

Finally, the paper presents a short review of the physical development, planning and objectives in building, etc.

The conclusion of the paper concerns prospects for future developments in Canada in engineering education from the point of view of the frame of experience presented in the paper.

AGM Paper No. 38

Foundation Failure of a Silo on Varved Clay

W. J. Eden, M.E.I.C. and M. Bozozuk, M.E.I.C., Research Officers, Soil Mechanics Section, Division of Building Research, N.R.C., Ottawa

This paper describes the collapse of a farm silo founded on normally consolidated varved clay near New Liskeard, Ont. The silo suddenly failed in July, 1961, the day after being filled to capacity. The 50 ft. high silo was founded at a depth of 4 ft. on a 22 ft. diameter concrete ring beam. Base loading was about one ton per square foot. The required shearing resistance of the subsoil according to bearing capacity theory is compared with field and laboratory measurements of shear strength.

AGM Paper No. 40

Earth Dam on Compressible and Pervious Foundation

C. F. Ripley, M.E.I.C., President, Ripley, Koohn & Leonoff Ltd., Vancouver, B.C.

D. B. Campbell, Senior Engineer, Ripley, Koohn & Leonoff Ltd., Vancouver, B.C.

Seymour Falls Dam is a main storage dam in the water supply system of the metropolitan area served by the Greater Vancouver Water District. The dam is a composite earth and concrete structure, designed to be built to an ultimate hight of 145 ft. in two or more stages. The first stage, 88 ft. high was completed in 1960.

Foundation conditions at the site presented several unusual geotechnical problems in the design and construction of the earth fill structures. A buried valley several hundred feet deep exists below the present floor of the Seymour River valley at the damsite. The earthfill section of the dam is founded on the coarse highly pervious sediments that occupy the buried valley. An impervious earth blanket extending upstream from the impervious core of the earth dam, has been employed to reduce foundation underseepage to tolerate limits. Tongues of highly compressible organic soil occur within the pervious foundations below the upstream shoulder of the dam and the impervious blanket. These sections of the dam were therefore designed to withstand the large foundation settlements that will occur under the water load of the reservoir.

The mean annual precipitation at the damsite is 144 in. This influenced the construction procedures and earth materials used in the impervious sections of the earth structures.

Observations of the performance of the structure are now available covering a full year of operation of the reservoir. Extensive observations and measurements of settlements, of hydrostatic pressures within the fill and foundation, and of seepage quantities during this period have provided an excellent opportunity for comparing the field behaviour of the structure with the design predictions.

The paper describes the unusual geotechnical problems arising from the difficult foundation conditions, and presents the results of performance observations to date.

AGM Paper No. 46

Kemano Tunnel Operation and Maintenance

J. B. Cooke, Consulting Engineer, (Dams, Tunnels, Hydroelectric Projects)
J. W. Libby, Assistant Chief Engineer & Vice-President, G. E. Crippen & Associates Ltd., West Vancouver, B.C.
J. T. Madill, Assistant Manager, Power Division, Operations Aluminum Company of Canada Ltd.

This paper gives the operating experience and history of the Kemano Tunnel from its in-service date of July, 1954, until the present. Special tests before draining in 1961 are described. The maintenance and repair program carried out from June 19 to September 11, 1961, is outlined from the points of view of design, organization and execution. Finally, operating results are shown.

AGM Paper No. 50

Sir Adam Beck No. 2 Pumped Storage Reservoir Observation of Performance

E. M. Taylor, Soil Mechanics Engineer, Ontario Hydro

Since the summer of 1957, a pumped storage reservoir has been in operation as part of the Sir Adam Beck No. 2 Development at Niagara Falls. The behavior of the reservoir, exposed to large daily drawdown, has been observed closely by measurement of pore pressures in the dike's impervious core and foundation, by measurement of seepage flow and by precise measurement of lateral and vertical displacements. Valuable experience was gained in determining the cause of a local failure through the clay core and in effecting its repair.

The reservoir was constructed to utilize water available from the Niagara River under the terms of the 1950 Niagara Diversion Treaty. The water is diverted nightly during the off-peak period and is used generally for peaking purposes during the day.

The storage reservoir was formed by the construction of a 3 million cu. yd. earth and rock fill structure about five miles in length.

The dike section consists of a rock fill zone, a sloping impervious core flanked by filter layers with upstream rockfill and riprap protection. The dike was founded mainly on impervious clays and silts except for a 3,000 ft. length founded directly on the pervious surface layers of the Lockport Dolomite rock.

Most of the reservoir area was sealed adequately with a natural cover of impervious soil. Local areas of shallow overburden and exposed rock required additional blanketing.

The structure was designed to withstand a drawdown of as much as 25 ft. daily. To observe the fluctuation of pore pressures with drawdown and thus substantiate the principal design considerations, a system of piezometers was installed within the impervious core.

During the summer of 1958, a local weakness in the foundation rock precipitated a form of stoping failure through the clay core which necessitated a complete dewatering, excavation, examination and repairs.

AGM Paper No. 51

Red Rock Falls Project

R. A. Forrester, Project Engineer H.E.P.C.

Red Rock Falls Generating Station is a hydro-electric station of 53,000 h.p., located on the Mississagi River, about 20 miles northwest of Blind River. It was completed in January, 1961, at a cost of approximately $17 million.

The main features of the project are the concrete gravity dam, sluiceways, log chute, intake and powerhouse containing two turbine generator units. Novel features are the electric governor, the spillway ski-jump energy dissipators and the remote control equipment.

This paper will deal with engineering and construction aspects, covering such items as site description, geology, hydrology, project layout, equipment installation, unit capacity, design highlights, construction progress and project organization.

AGM Paper No. 52

Forward Planning Studies Involving the Economic Full Supply Level of Manitoba Hydro's Grand Rapids Generating Station

L. A. Bateman, M.E.I.C., *Director of Production, Manitoba Hydro*

K. Renger, M.E.I.C., *Costing and Control Supervisor, Manitoba Hydro*

This paper will endeavor to outline some of the fundamental considerations underlying the choice of the full supply level for the Grand Rapids Development and show the extensive nature of the work involved in reaching a conclusion in this connection. The paper deals with a simulation study of the Manitoba Hydro Integrated Hydro-Thermal System in conjunction with the Grand Rapids and Upper Nelson River Sites Developments through a period from 1967 through 1975. The paper anticipates the effects of regulation on one of the largest natural water bodies in Canada—Lake Winnipeg.

AGM Paper No. 61

The Alignment of Large Diesel Engines

R. A. E. Stenberg, M.E.I.C., *Project Engineer, B. C. Power Commission*

The B.C. Power Commission in 1957 installed eleven 3,000 kw. generating sets, the prime movers of which were Cooper-Bessemer LSV-16 gas-diesel engines, at Quesnel, Prince George and Dawson Creek. These units were mounted on flat concrete bases and were grouted in a conventional manner using grout containing non-shrink additives containing iron particles and some calcium chloride.

In February, 1959, a crankshaft broke on No. 4 unit at Prince George. The breakage was a fatigue failure originating at a forging flaw, but because difficulty had been encountered in maintaining alignment of the engines, it was felt that a mis-alignment had accelerated the failure.

The failure of the crankshaft precipitated the decision to investigate the problem of recurring mis-alignment of the engines. This paper gives a brief history of the problem, the theory of the cause, the method of investigation to prove the theory, solutions investigated to solve the problem, solution chosen, execution of the solution and the results obtained.

AGM Paper No. 63

Convective Heat Transfer from a Helical Fin Tube in Longitudinal Flow

R. E. Chant, Professor and Head, Department of Mechanical Engineering, University of Manitoba

Established procedures and data for design involving convective heat transfer are not available for other than the most elementary components and geometric configurations. A design project for heat transfer equipment of any complexity becomes a development project, often consisting of collecting suitable data as well as prototype testing.

The tests were undertaken to investigate the effect of the fin efficiency on the convective heat transfer coefficient, to attempt to establish a representaive equivalent diameter and to provide additional data for longitudinal flow over a helical fin tube. The tests consisted of increasing the outside diameter of an annulus enclosing a heated helical finned tube in each of four tests. Air was forced over the finned element and data permitting the study of the convective heat transfer and the friction losses collected.

The geometric configuration of the finned element tested was such that the flow took place in the spaces between the fins as well as in the annulus beyond the tip of the fins. This led to the conclusion that the normal procedure of using the equivalent diameter derived from the annular flow area beyond the tip of the fins could not be universally used. Whereas an equivalent diameter determined from the total free cross-sectional area was satisfactory for all cases. It was further concluded that the use of the fin efficiency in determining the heat transfer coefficient facilitated the correlation of the results by the normal type of expression for flow in enclosed passages.

The heat transfer data obtained was compared to existing work and an expression representing the combined correlation is included.

Month to Month

Meeting of Executive Committee

The Executive Committee of the Institute met in Montreal on Saturday, March 10, 1962. President Ballard was Chairman of the meeting attended by 12 Councillors. Following are highlights of the deliberations.

Finance

Considerable interest was expressed in possible ways of obtaining more reasons for resigning from those members who choose to resign from the Institute. The co-operation of Branch Membership Committees will be helpful.

The meeting authorized the employment of a consultant to assist in the installation of and change-over to electronic data processing equipment.

Plans were made for continuing appropriate publicity of the need for increased membership fees.

Confederation

Dr. Ballard reported that a copy of the statement on Confederation issued by the E.I.C. Council on February 3, 1962, had been sent to the President of the C.C.P.E. Further discussions with the C.C.P.E. have not yet been held.

Plans are well advanced for a meeting with other Canadian learned technical societies to discuss the possibility of forming a Technical Societies Joint Council.

Membership Lists

Mimeographed Branch Membership Lists were distributed to all Branches in early March. Complete lists were also distributed to senior officers, committee chairman. These lists are a first attempt to indicate the field of technical interest of the membership. While incomplete, and with some inaccuracies, they are considered an excellent beginning for a regular publication of this information, which will be made possible with the electronic data processing equipment.

Committee on Research

A Committee on Research was constituted to function as a Division of the Committee on Technical Operations. The committee's basic responsibility is to continously alert the engineering profession to activities in research circles and its significance for the profession and the public. The end objective is the securing of maximum acceptance by engineers of the vital part research can play in the economic development of our country.

It is envisaged that the Committee on Research will function along two lines. Firstly, it should continously evaluate and determine the area of engineering technology werein specific research is desirable and draw such specific research need to the attention of appropriate research agencies. Secondly, the Committee should feed back to the engineering profession information on progress in research along the lines noted, as well as other research activities of interest.

Committee on Planning for the Future

Following Council's discussion of the "Future of the E.I.C." at its February 3rd meeting, a Committee on Planning for the Future was constituted, with Dr. G. MeK. Dick as Chairman.

Committee on Institute Building Program

A Committee on Institute Building Program was constituted to review current and future Institute needs for suitable headquarters facilities, located in the City of Montreal.

The function of this committee will be to review existing Headquarters premises, and determine if they can be adapated to meet the needs outlined above, and the capital and operating costs of such adapted premises. It will review the capital and operating costs of suitable Headquarters premises and will propose ways and means of financing such premises.

The Committee will also review the possibility of providing for future Institute needs for suitable Headquarters facilities in leased premises under a long term lease, and the capital and operating costs of such leased premises; and will engage consulting services, subject to submission to, and approval by, the Finance Committee and Council.

Management

The meeting received and considered proposals for a reviewed method of operation of the Council in the management of Institute affairs. These suggestions were turned over to the Committee on Planning for the Future for study and report within six months.

Technical Operations

A new Welding Technical Division and a new Thermal Technical Division were formed and appropriate action to constitute these technical divisions was instituted.

Emergency Measures Organization

The General Secretary reported that the name of the Engineering Advisory Committee has now been changed to Technical Advisory Committee. The 15 candidates to represent the E.I.C. at the Orientation Course for Engineers and Architects at the Civil Defence College, Arnprior, Ont., April 30 to May 4, 1962, had been selected.

Coming Events

Chemieal Institute of Canada, 45th National Conference. Edmonton, Alta. May 27-31.

Canadian Aeronautical Institute. Annual General Meeting. Montreal, May 28-29.

American Society of Mechanical Engineers. Summer Annual Meeting. Quebec City, June 10-14.

Engineering Institute of Canada. 76th Annual General Meeting. Montreal, June 12-15.

American Society of Agricultural Engineers. Annual Meeting. Washington, D.C. June 17-20.

American Institute of Electrical Engineers. Summer General Meeting. Denver, Col. June 18-22.

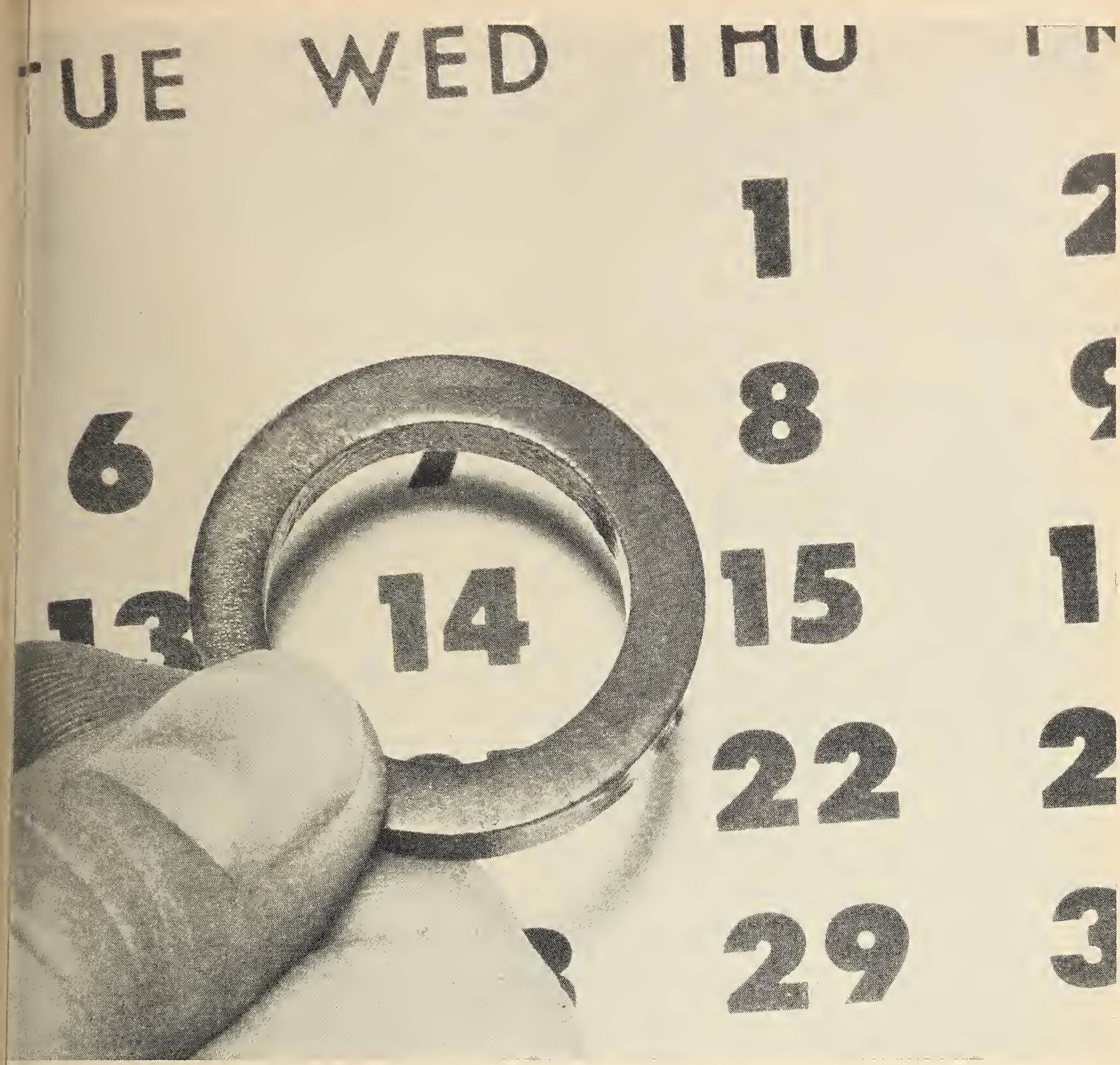
European Federation of Chemical Engineers. Chemical and Petroleum Engineering Exhibition. Olympia London, England, June 20-30.

American Society for Testing Materials. 65th Annual Meeting. New York. June 24-29.

American Society of Heating, Refrigerating and Air-Conditioning Engineers. 69th Annual Meeting. Miami. June 25-27.

American Society of Meehanieal Engineers, American Institute of Chemical Engineers. Fifth National Conference on Heat Transfer. Houston, Texas, Aug. 5-8.

American Institute of Electrical Engineers. Pacific General Meeting. San Francisco. Aug. 12-17.



How to specify roll-forged flanges without really trying (and get 'em within 14 days)

Our new ordering kit provides you with a convenient, fool-proof way to specify *any* flange you need. Flanges are available in straight carbon, alloy ferritic steels, and many austenitic steels. All are made according to strict ASTM specifications. Best of all, we ship *any* flange you need up to 80″ diameter and 10″ face within 14 days from the time you order . . . only Canforge makes them in Canada. Not only save time but also duty and exchange. We'll be glad to send you an ordering kit. Your request for it, quotations, or more information, will receive our immediate attention. Write:

CANADA FOUNDRIES & FORGINGS LTD. **Canforge** **WELLAND, ONTARIO**

The Engineering Institute of Canada
NOTICE OF BY-LAW AMENDMENTS

Council has made the following proposed amendments to the By-Laws of the Engineering Institute of Canada and has directed that they be mailed to the corporate members of the Engineering Institute of Canada in the May, 1962, issue of the Engineering Journal, to satisfy the requirements of Section 80 of the By-Laws.

Garnet T. Page, M.E.I.C.

General Secretary

PROPOSED BY-LAW CHANGES—1962

Engineering Institute of Canada

SECTION	PRESENT WORDING	PROPOSED WORDING	NOTES
20. **Entrance Fees**	The entrance fees, payable at the time of application for admission to the Institute, shall be as follows:	The entrance fees, payable at the time of admission to the Institute, shall be as follows:	1
21. **Annual Fees** (Proposed Heading)	Annual fees shall be due and payable on the first day of January for the calendar year then commencing, at which time a bill for the sum shall be mailed to each member, in accordance with the following schedule of fees:	Same	2

Present wording:

Members	**Montreal Branch Residents**	**All Other Branch Residents**	**Branch Non-Residents and Non-Residents**
Associate Members	$20.00	$18.00	$16.00
Students	9.00	7.00	6.00
Affiliates	2.00	2.00	2.00
	21.00	19.00	17.00

Proposed wording:

	All Branch Residents	**Branch Non-Residents and Non-Residents**
Fellows	$24.00	$22.00
Members	24.00	22.00
Associate Members	14.00	12.00
Students	3.00	3.00
Affiliates	25.00	23.00

SECTION	PRESENT WORDING	PROPOSED WORDING	NOTES
	Honorary Members shall be exempt from annual fees.	Same	
37. **Election of Nominating Committee**	The nomination of officers of the Institute shall be made by a Nominating Committee. The honorary councillors shall be ex-officio members of this committee. The remaining members, who shall not be officers of the Institute, shall be elected annually as follows: Each branch shall appoint one member, an additional member appointed by the Council shall be chairman of the committee. The membership of the committee shall be announced at the Annual General Meeting.	The nomination of officers of the Institute shall be made by a Nominating Committee composed of: (A) A representative from each branch, elected annually by the branch. (B) A representative from each zone appointed by Council from members of Council serving the final year of a tour of duty as a Councillor.	3

		(C) Honorary Councillors.	
		Categories (B) and (C) shall be concerned only with Presidential nominees.	
		Annually, Council shall appoint a Committee member from Category (B) to act as Vice-Chairman of the Nominating Committee for one year and as Chairman of the Nominating Committee for the following year, even though he may not be a Councillor during his second year of office. Such appointments shall be on a zone-rotation basis.	
		The membership of the Committee shall be announced at the Annual General Meeting.	
	Vacancies in the Nominating Committee as announced at the Annual General Meeting shall be filled by Council from the nomination or nominations submitted by the branch in which the vacancies occur.	Same	

38. **Meetings of Nominating Committee**	The Nominating Committee shall meet not later than the first of August to nominate officers for the ensuing year.	Delete	3
	Three members shall constitute a quorum, and members unable to be present may vote by letter.	Delete	

39. **List of Nominees for Officers**	The Nominating Committee shall prepare a list of nominees for officers, which shall contain the names of one or more nominees for each office to be filled, with the exception of that of president, for which only one name may be submitted.	Same	3
	A vice-president shall be elected by vote of the corporate members resident within the zone for which he is a candidate. One vice-president each shall be elected from Zones A and D and two vice-presidents each from Zones B and C. One of the vice-presidents for Zone C must be resident within twenty-five miles of the headquarters of the Institute.	A vice-president shall be elected by vote of the corporate members resident within the zone for which he is a candidate. Two vice-presidents shall be elected from Zone A, three from Zone B, two from Zone C and one from Zone D. One of the vice-presidents for Zone C must be resident within twenty-five miles of the headquarters of the Institute.	
	A councillor shall be elected by vote of the corporate members resident within the branch district for which he is a candidate.	Same	
	The list of nominees for officers shall be forwarded by the Nominating Committee to reach headquarters not later than the fifteenth day of September, for presentation to Council at a meeting to be held not later than the thirtieth day of September, and should be accompanied by a letter of acceptance of nomination from each nominee.	Before August 1st, the General Secretary shall prepare an initial letter to the members of the Nominating Committee, notifying them of the vacancies to be filled and nominations required. Branch representatives shall submit, by September 30th, direct to the Chairman of the Nominating Committee, nominations for Vice-Presidents and Councillors, together with letters of acceptance.	

		Branch representatives shall submit, by September 15th, to their zone representative, nominations for President. Zone representatives shall ensure that at least one, and preferably two or more, nominations for President (with biographies and branch affiliations), go forward from their zones, by October 15th, to the Chairman of the Nominating Committee. The Chairman of the Nominating Committee shall immediately send a list of all Presidential nominees (with biographies and branch affiliations) to the members of the Nominating Committee in Categories (B) and (C) and, at the same time, establish the order in which the Presidential nominees should be approached.	
	The Council shall examine the list of nominees for officers submitted by the Nominating Committee. If the Council find a nominee ineligible for the office for which he is nominated, or should the consent in writing of a nominee to appear on the list of nominees for officers not be furnished before the first meeting of Council in October, or should any nominee after such consent withdraw his name, such name shall be deleted, and, if necessary, the Council shall substitute another name therefor. The words "Proposed by Nominating Committee" and "Proposed by Council" shall be printed conspicuously on the list of nominees for officers, to indicate the manner of nomination of all nominees.	The Nominating Committee shall submit to Council, for examination, the list of nominees for officers. If Council finds a nominee ineligible for the office for which he is nominated, or should the consent in writing of a nominee to appear on the list of nominations for officers not be furnished before the meeting of Council in December, or should any nominee, after such consent, withdraw his name, such name shall be deleted and, if necessary, Council shall substitute another name therefor. The words "Proposed by Nominating Committee" and "Proposed by Council" shall be printed conspicuously on the list of nominees for officers, to indicate the manner of nomination of all nominees.	
40. Publication of Nominations	Not later than the seventh day of November, the secretary shall mail to each corporate member of the Institute, the list of nominees for officers, as prepared by the Nominating Committee and the Council.	The list of nominees for officers shall be published in the Journal of the Institute not later than the January issue, preceding the Annual General Meeting.	3
41. Additional Nominations	Additional nominations for the list of nominees for officers signed by ten or more corporate members and accompanied by written acceptance of those nominated, if received by the general secretary on or before the first day of December, shall be accepted by the Council and shall be placed on the offieers' ballot. The words "Special Nomination" shall be printed conspicuously near such names, and the names of the members making sueh nominations shall be printed on some part of the officers' ballot.	Additional nominations for the list of nominees for officers may be accepted from corporate members prior to the first day of March. Such additional nominations shall be signed by ten or more corporate members, and be accompanied by the written acceptance of those nominated. These additional nominations shall be sent direct to the General Secretary, considered by Council, and, if accepted, placed on the officers' ballot. The words "Special Nomination" shall be printed conspicuously near such names, and the names of the members making such nominations shall be printed on some part of the officers' ballot.	3

42.	**Officers' Ballot**	A ballot form, prepared in accordance with the list and additional nominations (if any) shall be mailed to corporate members at least thirty days before the Annual General Meeting (except as noted in the last clause of this section), and shall state the name and residence of each nominee, his class of membership and the zone or branch district in which he resides. The names of the nominees for each office shall be arranged alphabetically by zones and branches.	Same	3
		Voters may strike out names from this officers' ballot and may substitute other names therefor but the number of votes cast for each office must not exceed the number to be elected to such office. In voting for councillors, each voter shall vote for the councillor to be elected from his own branch. Directions in accordance with the above provisions shall be printed conspicuously on the officers' ballot and any vote which does not comply with them shall be rejected.	Same	
		In the event of only one name being submitted for any office prior to December 1st, Council shall declare that nomince elected by acclamation.	In the event of only one namc being submitted for any office prior to the first day of March, Council shall declare that nominee elected by acclamation.	

45.	**Appointment of General Secretary, Treasurer and Committees**		New first paragraph — There shall be an Executive Committee of the Council which shall be composed of the President, the Vice-Presidents, the Immediate Past President, the Treasurer, and the Chairman of such Standing Committees as shall be determined from time to time by Council. Five members of the Executive Committee shall constitute a quorum. Members of Council not included above are invited to attend meetings of the Executive Committee and to offer opinions, but will not vote. The Executive Committee shall meet at least seven times during the Institute's year.	4
		The Council shall meet within seven days after its election and shall then appoint the general secretary, the treasurer, and the following standing committees.		
		A Finance Committee of five members, including the treasurer. The treasurer shall be ex-officio vice-chairman of the Finance Committee.	Same	
		A Library and House Committee of five members.		
		A Committee on Technical Operations of at least six members.		
		A Publications Committee of five members.		
		A Legislation Committee of three members.		

		An Admissions Committee of at least five members, three to constitute a quorum.		
			A Committee on Membership of at least six members.	
			A Committee on Branch Operations of at least six members.	
		The chairman of each standing committee shall be a member of the Council.	The chairman of each standing committee shall be ex officio a member of the Council.	
		Standing committees shall perform their duties under the supervision of the Council, and shall report to the Council.	Same	

55.	**Meetings of Council**	Council shall meet at least once every two months, from October to May. Additional meetings that may be deemed necessary to conduct properly the business of the Institute shall be held at the call of the president.	Council shall meet at least three times during the Institute's year to conduct such business as may come before it, and to review the actions of the Executive Committee.	5
			Ordinary meetings of Council shall be held immediately before the Annual General Meeting, immediately after the Annual General Meeting, and on another date during the year, at the call of the President.	
			Extraordinary meetings may be held at any time at the call of the President, or on the written request of ten councillors addressed to the General Secretary. He shall give seven days' notice, and shall arrange that the notice be accompanied by an agenda and necessary documentation.	
		Five members shall constitute a quorum.	Same	

79.	**New By-Laws — Amendments — Repeal** *(Second para. — Second sentence)*	The general secretary shall issue the letter ballot not later than two months after the Annual General Meeting.	The General Secretary shall issue the letter ballot not later than six months after the Annual General Meeting.	6

NOTES TO MEMBERSHIP

1. The present requirement that entrance fees be submitted with an application is rather awkward. Reference: Executive Committee Meeting, August 18/61 — Minute 61/595.

2. This matter has been under consideration for some time, and was included in the proposed amendments last year. Under Minute 61/678 of the Council Meeting on September 23, 1961, the Chairman of the Finance Committee reported that the membership had not accepted the proposal to increase fees. During the discussion, it was pointed out that Council might have better prepared the membership for this increase, but that this was impossible because of the By-law requirement for ballots to be mailed within 60 days of the Annual Meeting.

3. The procedure in the present By-laws for the Nomination and Election of Officers is difficult to follow. A special committee appointed by Council studied the procedure and reported to the Executive Committee Meeting of August 18, 1961.
   After approval by Council, these By-law changes are based on the report of the Commitee — Minute 61/768.

4. The membership of Council is so large (91 members) as to be difficult to assemble and slow in executive action. Rather than disturb the function of the Council in providing a means for communication both ways between each branch and Council, while at the same time speeding up the handling of many items of Institute business, an Executive Committee of Council has been in operation on a trial basis since the formation of the 1960 Council. This action was taken by resolution of Council. Minute 61/780 required the By-law Committee to prepare appropriate amendments to provide for appointment of the Executive Committee along the lines established during the trial period.

5. With the appointment of the Executive Committee, it is not necessary for the Council to meet as frequently as was the former practice.

6. The present By-law does not allow time for explanation, through branch meetings, of the circumstances and background of letter ballots. Minutes 61/678 and 61/679— Council Meeting of September 23, 1961.

FREDERIC LEWIS LAWTON

President
The Engineering Institute of Canada
1962-1963

FRED LAWTON is an "impatient" engineer.

He doesn't demand perfection, but he becomes impatient with less than all-out effort; he is far from tranquil when someone suggests a devious approach to a problem rather than the direct approach; more than anything else he seems impatient with the 24-hour day, the seven-day week.

Making one day do the work of two is a long-time habit with the 1962-63 President of the Engineering Institute of Canada.

HE WAS born in London, England, on December 14, 1900, and was brought to Canada by his parents as a youngster. After moving from Alliston, Ont., to near Cookstown where Lawton attended Cookstown Continuation School the family moved on again to Toronto.

During one year Lawton worked as a cub reporter for the Toronto Telegram. The working of the presses fascinated him, and he still feels he has a drop of printer's ink in his veins.

An instructor at a night technical school in Toronto advised the young student to start charting his course. As his inclination was towards engineering this meant more work on mathematics. One day had to do the work of two but eventually, after working days for the Toronto Street Railway and nights attending classes at Jarvis Street Night High School, he graduated in Honour Mathematics.

IN 1923, Lawton graduated from the University of Toronto, having earned his B.A.Sc. in Electrical Engineering, with Honours. During two of his summers while attending university he worked in the gold mines of the Timmins area.

After graduation he joined the Test Course and took an advanced engineering course at the General Electric Company in Schenectady, N.Y., where he gained first-hand knowledge of such things as industrial control, large and small motors and generators. During the latter part of his work there he was in charge of large-scale shop tests designed to substantiate theories underlying long-distance transmission-system static and transient stability.

IN DECEMBER, 1925, Lawton joined the Quebec Development Company as an assistant electrical engineer at the Isle Maligne project. From that point he progressed steadily through Duke-Price Power Company, Limited (later Saguenay Power Limited), Aluminium Company of Canada, Limited, and since 1948, with Aluminium Laboratories Limited, which is the research and development subsidiary of Aluminium Limited.

As Head of the Power Division for Aluminium Laboratories, and later as Vice-President, Lawton's duties include responsibility for hydroelectric and other power investigations, estimates for development in the Americas, Europe, Africa and Asia, and consulting services in the power field for Aluminium Limited subsidiaries.

SINCE APRIL, 1957, Lawton has been a Director of Saguenay Transmission Company, Limited, and of Saguenay Power Company, Limited.

His work keeps him travelling and there are few major countries, including Russia, which he has not yet visited. His travels help him accommodate one of his hobbies—photography.

IN 1927 he married Viola Dubé, and they have four sons and two daughters. None of the other members of this bilingual household is an engineer, although Lawton still has hopes that at least two of his sons will follow in his footsteps.

Thus far in his career he has presented about 40 major papers. He is a member of numerous important international societies, and it concerns him that Canadian engineers often are accepted for their excellence more readily in foreign countries than in Canada.

LAWTON'S first major responsibility within the Institute came in 1937 when he was chosen Chairman of the Saguenay Branch. Since that time he has also served as Montreal Branch Chairman, Councillor, Chairman of the Committee on Technical Operations, Vice-President for the Province of Quebec, Chairman of the Finance Committee, and Chairman of the Committee on Branch Operations.

DURING HIS career as an engineer he has given thought to a great many facets of the profession. Following are his observations on a few of them.

Longer Engineering Courses—"A hard-working student can accomplish plenty in a four-year course. What is accomplished depends entirely upon the individual. There is no golden secret to success, except hard work, in engineering or in any other field."

Engineering Fields—"Many engineers are doing work for which they are not specifically trained. But by its very nature this work requires a trained mind. A period of stuly and training is not intended to turn out a narrow specialist, but rather an adaptable person."

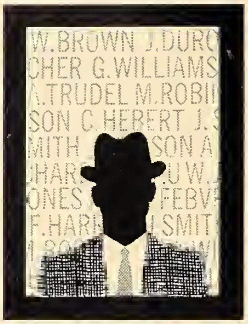
Russian vs. Western Engineering Training—"The basic aim of the U.S.S.R. has been and is the development of competent trained technical people to serve the needs of the state. These frequently have, as a result, a circumscribed outlet. In the West the basic aim is the development of well-rounded engineers who have a fair knowledge of the humanities and social requirements to back up a rather good training in basic engineering sciences. The objectives of Western engineering training are the development of skilled engineers and capable citizens."

Canadian Engineers—"Canada has developed many outstanding engineers in many disciplines. Many have achieved world-wide recognition, particularly in mining, power, pulp and paper, aviation and electronics."

AS AN engineer of broad outlook Lawton is a strong supporter of the Institute, which he feels helps the engineer assume his responsibilities and enables him to keep abreast of developments throughout his professional life.

And the 1962-63 President of the Engineering Institute of Canada can be very impatient with engineers who fail to assume the responsibilities of their profession.

Personals



A. M. Hurter, M.E.I.C. (McGill '46), a partner in the firm of Stadler, Hurter and Company, has become President and Director of Stadler, Hurter International Ltd., of Montreal, a firm which carries out consulting services to the pulp, paper and power industries outside Canada.

Hugh A. Krentz, A.M.E.I.C. (Man. '57) has been appointed to the newly created position of Development Engineer at the Canadian Institute of Steel Construction. Mr. Krentz joined CISC in 1960 as Regional Engineer of the Central Region, covering Saskatchewan and Manitoba. Prior to this, he worked on many civil engineering projects with consulting engineers in Manitoba. In his new position, he will be responsible for research and development work in connection with plate structures in the construction industry.

George J. Sladek, M.E.I.C. (Man. '50) has been appointed assistant chief engineer for Gibb, Underwood & McLellan, Consulting Engineers of Toronto. Prior to joining the firm in 1960, Mr. Sladek was special projects engineer for the firm of Underwood, McLellan and Associates Ltd., a partner with Sir Alexander Gibb and Partners in the firm of Gibb, Underwood, McLellan. Mr. Sladek was a member of the team which designed the Iroquois turbojet engine. Mr. Sladek has made a special study of northern development at Thompson, Man., and has carried out studies for the redevelopment of the Churchill area for the Manitoba and Federal Governments. Recently, Mr. Sladek has been connected with the latter stages of the design for the Federal Department of Public Works' Lakehead Harbour Terminal at Port Arthur-Fort William, and a 275 ton floating self-propelled revolving crane for the St. Lawrence Seaway Authority.

K. R. Meyer, M.E.I.C. (Univ. London '37) has become a partner in the firm of Stadler, Hurter & Company, Consulting Engineers of Montreal. Mr. Meyer has also been appointed Vice-President and Director of the firm of Stadler, Hurter International Ltd., which is owned by the partnership.

W. L. Todd, P.ENG., M.E.I.C. (McGill '41) has become a partner in the firm of Stadler, Hurter & Company, Consulting Engineers in Montreal. Mr. Todd, who is also President of Stadler Hurter International Ltd., has had wide experience in the pulp and paper, power and other industries.

Sydney Sillitoe, M.E.I.C. (U. of Alta. '31) has been appointed Chairman of the Belleville Transit Commission. Mr. Sillitoe has served for two years on the Commission. He is Chairman of the Committee on Technical Operation of the Engineering Institute of Canada, and is an ex officio member of its Council.

C. Jacques Gauvin, A.M.E.I.C. (Poly. '54) has recently accepted the position of Chief Geologist for Liberian American-Swedish Minerals Company (Lameo) on the Nimba River, Liberia. Mr. Gauvin was formerly Chief Geologist for Steep Rock Iron Mines Limited, Steep Rock Lake, Ont.

Gaston Galibois, M.E.I.C. (Laval '50) has been nominated Manager of Engineering Construction at the Quebec Power Company.

Dr. John A. Havers, M.E.I.C. (U. of Sask. '47, Purdue '56) has joined the staff of the Armour Research Foundation of the Illinois Institute of Technology in Chicago, as a Research Engineer in the Structural Mechanics section. Prior to joining Armour Research Foundation, Dr. Havers was an associate in the firm of Harland, Bartholomew and Associates, Consultants and was Director of Engineering in the Honolulu office of that firm since 1956. He worked in Canada and the United States on highway projects involving research, design and construction.

John R. Dunn, M.E.I.C. (Toronto '38) has been appointed Manager—Tube Section at Canadian General Electric's Electronic Equipment and Tube Department. Mr. Dunn was engaged in the sales planning of commercial electronic equipment and administration of contracts for development and production of military electronic equipment. In 1955, he transferred to the Electronic Tube Section where he was responsible for Marketing Research and Product Planning of Electronic Tubes and Semiconductors. He was appointed Manager —Marketing in 1961.

Frank Block, M.E.I.C. (Tech. U., Vienna '21), has been appointed consulting engineer to the manager of the Boiler Products Division of Dominion Bridge. Prior to joining the company in 1938, Mr. Block was head of the boiler department for Simmeringer, Maschinen & Waggon in Vienna.

J. E. Ewanchyna, M.E.I.C. (Sask. '55), former Process Design Engineer in the Petrochemicals Department at Polymer Corporation, Sarnia, has been appointed Senior Process Engineer in charge of utilities and waste disposal.

News of the Branches

Amherst District

R. R. McIntyre, M.E.I.C.
Correspondent

A special meeting was held March 9 at the Fort Cumberland Hotel to discuss the issue of Confederation as proposed by the Engineers Confederation Commission. W. D. Hagen was Chairman of this meeting, the last in a series arranged by the Branch Executive to discuss the role and responsibilities of the Engineering Institute of Canada and the Provincial Association. The meeting ended with a panel discussion.

Plans were made for entertaining the engineering students at Mount Allison University at the April meeting. Plans were also made for ladies night to be held May 11 at which time members and their wives will hold a lobster banquet underground in a Cumberland mine.

Central B.C.

A. F. Joplin, M.E.I.C.
Correspondent

C. F. Ripley, of Ripley, Klohn & Leonoff Ltd., Vancouver, was the guest speaker at the Branch's March 16 meeting at Penticton. The topic of his talk "Dams Around the World" was illustrated by slides. Mr. Ripley reviewed the engineering of the foundations for dams in Norway, Sweden, Holland, Denmark, Italy, Switzerland and France in Europe, and Hong Kong, Japan, Hawaii and the Philippines as well as Canada. This international study was undertaken as part of Mr. Ripley's leave of absence from his consulting firm. Mr. Ripley said that dam foundations were as much an art as an exact science, and that it was not always possible to reduce the problems of the engineering of a foundation to a rational solution since the foundation materials could not be expected to follow the rough mathematical assumptions that were made prior to the construction.

The General Secretary of the Engineering Institute was also a guest at this meeting. He spoke on Confederation, and the Institute Library.

Corner Brook

R. G. Scott, A.M.E.I.C.
Correspondent

The Branch held a meeting February 27 at which Kevin St. George, Superintendent of the Mechanical Department at Bowater's Newfoundland Pulp and Paper Mills Limited, was the guest speaker. In his talk entitled "Maintenance Engineering", Mr. St. George described the duties of the Research, Design, Construction and Maintenance groups which participate in the installation of new plants or equipment. He emphasized that eventual cost of maintenance is closely tied to the first three and that design engineers in particular should always work with the problems of maintenance in mind. The maintenance problems of no two plants are alike, varying with the type of process, plant and equipment and the local conditions and attitude of the management. The common aim of all plants however is to keep process interruptions to a minimum, obtain maximum economic life from equipment, and at the same time reduce costs. To do this requires adequate planning, close control and effective use of available men and equipment.

Edmonton

W. Rutherford, M.E.I.C.
Correspondent

The Structural Group of the Branch held a successful technical meeting February 7 in the Math Physics Building of the University of Alberta. J. Longworth was chairman at this meeting attended by 60 members. The guest speaker was G. Adam, Managing Director of Conforce Products Ltd., Calgary. Mr. Adam described the design, erection and other features of the prestressed concrete girders used in the construction of the Red Deer River on Alberta highway 36 north of Duchess. The girders are the second largest of their type used in Canada. The twenty girders are 148 feet long, 9½ deep, and weigh 110 tons. Mr. Adam illustrated his talk with color slides taken during construction of the bridge.

Mr. Adam was assisted in his talk by D. deWolf, and T. Lamb of Lamb, McManus and Associates, and by T. Trimble of the Bridge Branch, Department of Highways. A lively question-and-answer period followed the well-attended talk.

The Branch intends to continue these technical meetings, varying the subjects with appeal for the largest possible cross section. Another technical meeting is planned for April.

A meeting of the Branch's Electrical Engineering Section was held at the University of Alberta, February 8. R. E. Phillips, Section Chairman for the evening, introduced Branch Chairman, Adam Sandilands to the members present. Professor J. A. Harle introduced the speaker Phillip Richardson, Deputy Chief Electrical Engineer for C. A. Parsons and Co. Ltd., Newcastle-on-Tyne, England, who spoke on "Developments in Large Turbo Type Generators".

Mr. Richardson discussed various planned faults that had been placed on a transmission grid in England in order to secure information on the system and alternator response and behaviour. Much valuable information had been secured on generator operation during abnormal excitation conditions. Research into slip ring and brush operation at high current values was discussed. Results of tests carried out to determine transient shaft torques on large turbo alternators were shown. Mr. Richardson indicated with use of slides, the recent developments in the field of water cooling in alternator stators, a feature which has permitted great increases in size. Details of stator bar ends for both water and electrical connections to the hollow conductors were discussed.

D. L. MacDonald expressed the appreciation of the group for a most interesting and well prepared paper.

On February 19, Dr. B. G. Ballard, President of the Engineering Institute of Canada, visited Edmonton where he was interviewed by television, radio and representatives from local press. Dr. Ballard conveyed through these mediums, information on Engineering education, Confederation of Engineering associations and the future role of Engineers in Canada. Dr. Ballard was accompan-

(Continued on page 98)

Library Notes

Prepared by the Library, The Engineering Institute of Canada

Book notes marked by an asterisk have been provided through the courtesy of The Engineering Societies Library in New York.

BOOK REVIEW

MANAGEMENT GUIDE FOR INDUSTRIAL SUPERVISORS.

A guide to the selection of supervisors, and to the supervisory ideas and techniques in use at present. The authors first consider the choice and training of an industrial supervisor, and the position of the supervisor in the management team. Other chapters cover industrial psychology, the development and training of subordinates, the problems of obtaining and handing out information, special supervisory problems such as cost reduction, methods improvement and quality control. (B. T. Lewis and W. W. Pearson. New York, Rider, 1961. 66 p., $1.40.)

THE MACHINISTS.

A scholarly study of the history of the International Association of Machinists, based on a study of the Union's own records. The first section of the book covers the history of the Union, and includes the jurisdictional, racial and section disputes, and the later fights between "pure" and "political" unionism. The second section discusses its government, its membership, revenues and expenditure, while the last section deals with its policies, its relations with other unions, with employers and with the community. (Mark Perlman. Cambridge, Harvard, Toronto, Saunders, 1961. 333 p., $9.00.)

AVIATION AND SPACE DICTIONARY, 4th ed.

Definitions of ten thousand terms used in aviation, aerospace and related subjects such as atomic energy, electronics, meteorology, navigation, television, etc. The definitions are clear and concise, many cross-reference are included, as are illustrations. A very useful addition to anyone's library. (Ed. by E. J. Gentle and C. E. Chapel. Los Angeles, Aero, 1961. 444 p., $10.00.)

CERAMICS.

When translating this volume from the fourth German edition, some illustrations from English sources have been included, as has some of the material found in the third German edition, but omitted from the fourth. The text is both a critical review of research in ceramics, and a concise work of reference.

The first section of the book covers the structure and properties of silicates and glasses, and the chemistry and physics of clay, silica, feldspar and glazes. The second section of the book is concerned with ceramic products from the chemical point of view, and covers bricks, refractory materials, terracotta and earthenware, stoneware, porcelain and electrical insulators. Innumerable references are included, the majority being to German publications. (Hermann Salmany. Toronto, Butterworth, 1961. 380 p., $12.50.)

ON RETRIEVAL SYSTEM THEORY.

The problem of storing and retrieving information becomes daily greater, and the search for new methods continues. This volume contains a unified presentation of the whole problem, taking a theoretical rather than an empirical approach. The author considers the description of documents; the terms used to indicate the subject of a document; the descriptor languages; methods of classifying; file organization and coding; methods of conducting a search; the automation of storage and retrieval. References are included for further reading. (B. C. Vickery. Toronto, Butterworth, 1961. 159 p., $5.75.)

THE ENGINEERING INSTITUTE LIBRARY

The publications mentioned in these notes are now available in the Library, and may be borrowed by members of the Institute. Two items may be borrowed at one time for a period of two weeks, excluding time in transit.

Library hours are: Monday to Friday: 9 a.m. to 5 p.m.; Saturdays: 9 a.m. to 12 noon. All requests and enquiries should be addressed to the Librarian at 2050 Mansfield Street, Montreal.

GAS CHROMATOGRAPHY.

The subject of gas chromatography has expanded rapidly in the last ten years, so that it is no longer possible to obtain a grasp of it by referring to the original literature. This survey volume provides a basic introduction to the subject, and gives the technologist enough information to enable him to construct his own apparatus.

The book is mostly concerned with gas-liquid chromatography. The apparatus is described, the column and its packing, methods of sample injection, and detectors, including katharometers, gas-density meters, flame/thermocouple and ionization detectors. Other chapters cover retention parameters, column performance, high efficiency columns, qualitative and quantitative analysis, gas analysis, and the use of gas chromatography as a preparative technique. Many references are included for further reading. (D. Ambrose and B. A. Ambrose. London, Newnes, 1961. 220 p. £2.)

SMALL AND MEDIUM POWER REACTORS VOL. 1.

The first of two volumes of the proceedings of a conference, held in 1960 by the International Atomic Energy Agency, to study the technology and economics of small and medium power reactors, and their role in meeting world energy problems. This volume presents a general review of reactor systems, and experiences gained in their construction and operation. All but three of the 35 papers included are in English, one is in French, and two in Russian. The papers were given by experts from all over the world, and include two from Canada, on heavy-water-moderated reactors. (Vienna, I.A.E.A., 1961. 617 p., $9.00.)

***SYMPOSIUM ON METHODS OF METALLOGRAPHIC SPECIMEN PREPARATION.**

Reviews of established methods and reports of new techniques are presented. Many of the techniques described were developed for the preparation of some of the newer metals, alloys, and ceramic materials used in aerospace and nuclear applications. (Philadelphia, American Society for Testing and Materials, 1961. 134 p., $4.50 s.t.p. 285.)

(Continued on page 102)

SENIOR ENGINEERS

Our Company has a few vacancies for Mechanical, Chemical, Civil & Electrical Engineers to supplement our existing experienced staff. Preference will be given to applicants with ten years or more experience in the pulp and paper industry and all commensurate salary requirements will be given consideration.

Scope of Work

Project Engineering on all facets of pulp and paper mill design for a world wide clientele.

Employment Benefits

Pension Plan
Health Insurances
Group Life Insurance
— All Company Participated

Although appointments could be made almost immediately, the ideal candidates will probably have commitments which may take some time to complete. This we appreciate.

All replies will be treated in strictest confidence.

Write: **Personnel Manager,**
H. A. Simons (International) Limited,
16 East Hastings Street,
Vancouver 4, B.C.
File No. 159-V.

ENGINEERING SALES

Positions are open in a rapidly growing established company for high calibre sales representatives. A degree in engineering or science, preferably emphasizing chemistry and obtained since 1958 is desirable. Experience in sales, pulp and paper, refinery or metallurgical plant would be helpful. Relocation may be necessary and travelling required. Remuneration above average and advancement possibilities excellent. Kindly apply in writing, outlining academic qualifications, experience and interview availability, to:

ALCHEM LIMITED

BURLINGTON, ONTARIO

File No. 160-V.

OFFICES FROM COAST TO COAST

WATER CONDITIONING CHEMICALS AND SERVICES • COAGULANTS • PETROLEUM CHEMICALS • CORROSION INHIBITORS • PROCESS ANTIFOAMS • MICROBIOCIDES

MISCELLANEOUS

MECHANICAL OR CHEMICAL ENGINEER required by company making marine products. Require 2 to 5 years applicable experience. Suggested age 23-30; preferably resident in Nova Scotia. Salary according to qualifications and experience. File No. 135-V.

ENGINEERS FOR MANAGEMENT—project, design, sales, research, development and control. Graduates of most types and ages required by clients of the Technical Service Council, a non-profit, industry-sponsored placement service. Write 2 Homewood Ave., Toronto 5, Ontario or 1500 Stanley Street, Montreal 25, Que. for an application. There is no charge for work done on your behalf. File No. 6648-V.

HYDRONIC HEATING SALES ENGINEER with successful sales record in the Montreal area wanted for new Quebec office by Toronto manufacturer. Include complete resume of education, experience, marital status. Salary commensurate with ability. Excellent company benefits. All applications will be treated confidentially and should be made in writing to File No. 156-V.

SALES ENGINEERS — with B.Sc. degree required by fully integrated major oil company, marketing department, for early assignment in Western Canada. If you believe SALES is a true engineering function, then your future professional life can fit this position. Training course given. Excellent remuneration and advancement prospects. Three to five years sales experience desirable but not a requirement. Knowledge of modern industrial equipment a definite asset. Permanent position. Full company benefits. Please give personal history and statistics. File No. 157-V.

CITY OF BELLEVILLE — Applications are invited for the position of City Engineer. The successful applicant will be placed in a salary scale of $8,000-$10,500 in accordance with qualifications and experience. Duties include the direction and co-ordination of the planning, designing, construction and maintenance of Public Works, including roads, sidewalks, bridges, sewers, etc. Applicants must be registered Professional Engineers, and have experience in the Municipal Engineering field. Applications, stating personal details and experience, together with the names and addresses of three persons to whom reference may be made, must be submitted no later than June 5th, 1962, to: A. L. Jobey, Personnel Officer, City Hall, Belleville, Ontario. File No. 163-V.

SALES ENGINEER required for challenging position in the rapidly growing field of Prestressed, Precast Concrete. Applicant should be young and personable with 3 to 5 years' experience in the Structural Steel or Precast Concrete fields, some sales experience desirable. Position requires mostly contact with Architects and Consultants plus estimating and supervision of sales literature preparation and associated draughting. All usual benefits plus car expenses. Send complete resume and salary expected to P.O. Box 3599, Winnipeg 4, Manitoba. File No. 126-V.

JUNIOR TRAFFIC ENGINEER—To make professional road planning, traffic and parking studies, reports and recommendations, relating to channelization, design, street widening, realignments, grade separations, and general traffic movements etc. Supervise small technical staff. Salary —$4400—$7000 depending on experience. Qualifications—Graduate Engineer, preferably with 2 or more years road traffic specialization or experience. Apply to Personnel Coordinator, The City of Calgary, Alberta. File No. 162-V.

TEACHING

UNIVERSITY OF SASKATCHEWAN. Teaching in Civil Engineering. Applications are invited for a teaching position as Lecturer or Assistant Professor in Civil Engineering. Minimum requirements—Master's degree. Duties consist of teaching in structures at undergraduate and post-graduate level. Minimum salaries—Lecturer $6,500. Assistant Professor $7,000. Associate Professor $9,000. Professor $11,-700. Direct applications to Head, Department of Civil Engineering, University of Saskatchewan, Saskatoon, Sask. File No. 155-V.

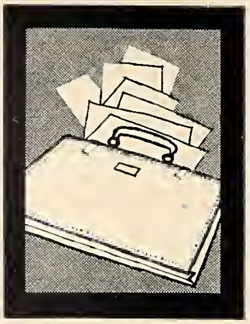
Research Opportunities for CIVIL ENGINEERS in the field of ENGINEERED WOOD PRODUCTS AND STRUCTURES

Up to $10,300 per annum

Required immediately for two attractive appointments with the Forest Products Laboratory **FEDERAL DEPARTMENT OF FORESTRY, OTTAWA, CANADA** Post-graduate training in structures or mathematics desirable, but not mandatory. Responsible experience in structural timber research essential. For details and applications, write to the

CIVIL SERVICE COMMISSION, OTTAWA, CANADA.
Ask for Circular 62-1255.
File No. 161-V.

Business and Industrial Briefs



Appointments and Transfers

John J. Norris has been appointed to the Board of Directors of Montreal Locomotive Works Limited. Mr. Norris, a Vice-President of the company, also serves as comptroller and treasurer. Mr. Norris joined the company in 1940.

George A. Tinnerman III has been appointed General Sales Manager of Dominion Fasteners Limited, Hamilton. Mr. Tinnerman will be responsible for the company's line of plastic fasteners and GAT fasteners for the building and construction industries.

David M. Blair has been appointed Sales Manager, Administration, and **W. G. Harris** to the position of Sales Manager, Marketing at Darling Brothers Limited. A. J. Nicle has relinquished his position as Sales Manager of the Company. He will be associated with the company in an advisory capacity.

F. S. Heeley has been appointed engineering manager for the Switchgear and Control Division of Canadian Westinghouse, Hamilton. Mr. Heeley has many years' experience in system and station design and planning with power utilities in Brazil, England and Canada. He also has extensive experience in product development and manufacturing.

Sylvester (Sy) Szabo has been appointed Vice-President and General Manager of Robertshaw-Fulton Controls (Canada) Limited. Mr. Szabo has had extensive experience in the domestic appliance manufacturing industry.

C. K. Dewar has been appointed commodity sales manager, Moulded Goods and Special Products, Dominion Rubber Company's Mechanical Goods Division, Montreal. Mr. Dewar joined the company in 1943 as a development chemist and was transferred to the sales department of the Mechanical Goods Division in 1951 where he was placed in charge of new products sales development.

John D. MacNaughton has joined the Special Products Division of the DeHavilland Aircraft of Canada Limited, as Chief Mechanical Development Engineer. Mr. MacNaughton will be responsible for the development of the Division's Mechanical product lines.

Kenneth R. Oswell has been appointed a vice-president and director of the Ontario Division of Payne-Ross Limited.

J. W. Bishop has been appointed Vice-President of Ingledow Kidd & Associates Limited, Consulting Engineers. He will establish a branch office of the firm in Colombo, Ceylon, from which he will maintain contact with engineering activities of the organization in India.

M. Bruce Mairs has been appointed Vice-President of Canadian operations of H. K. Porter Company (Canada) Limited. He will continue in his present capacity as General Manager. Prior to joining Porter in 1960, Mr. Mairs had been associated with Joy Manufacturing in Canada and the United States.

AN IMPROVED UNIVERSAL oil that features a minimum flash point 10 degrees higher than that of previous types is being specified as standard on all Canadian Westinghouse transformers and circuit breakers. The oil has a flash point of 145 degrees C, 293 degrees F. The oil's physical, chemical and electrical properties make it applicable to all equipment where the conventional insulating type had been used.

SILICONE/ALUMINUM PAINTS which are able to withstand extremely high working temperatures for long periods have been introduced by David Brown (Canada) Limited of Toronto. These paints are resistant to most chemicals at moderate temperatures, and are affected very little by the weather. The paints are intended mainly for maintenance work, protective coatings on industrial equipment, and decorative finishes for some domestic appliances.

AVAILABLE FROM Martin Black Wire Ropes Canada Ltd., is a new, stronger grade of wire rope designed specially for heavy duty construction equipment, shovels, back-hoes, draglines and scrapers. Carbon steel rod with precise properties was selected, drawn into wire to rigid specifications. The wire is available in I.W.R.C. Lang's Lay, on half to one inch in diameter. It is marked by a colored strand for easy identification.

Developments

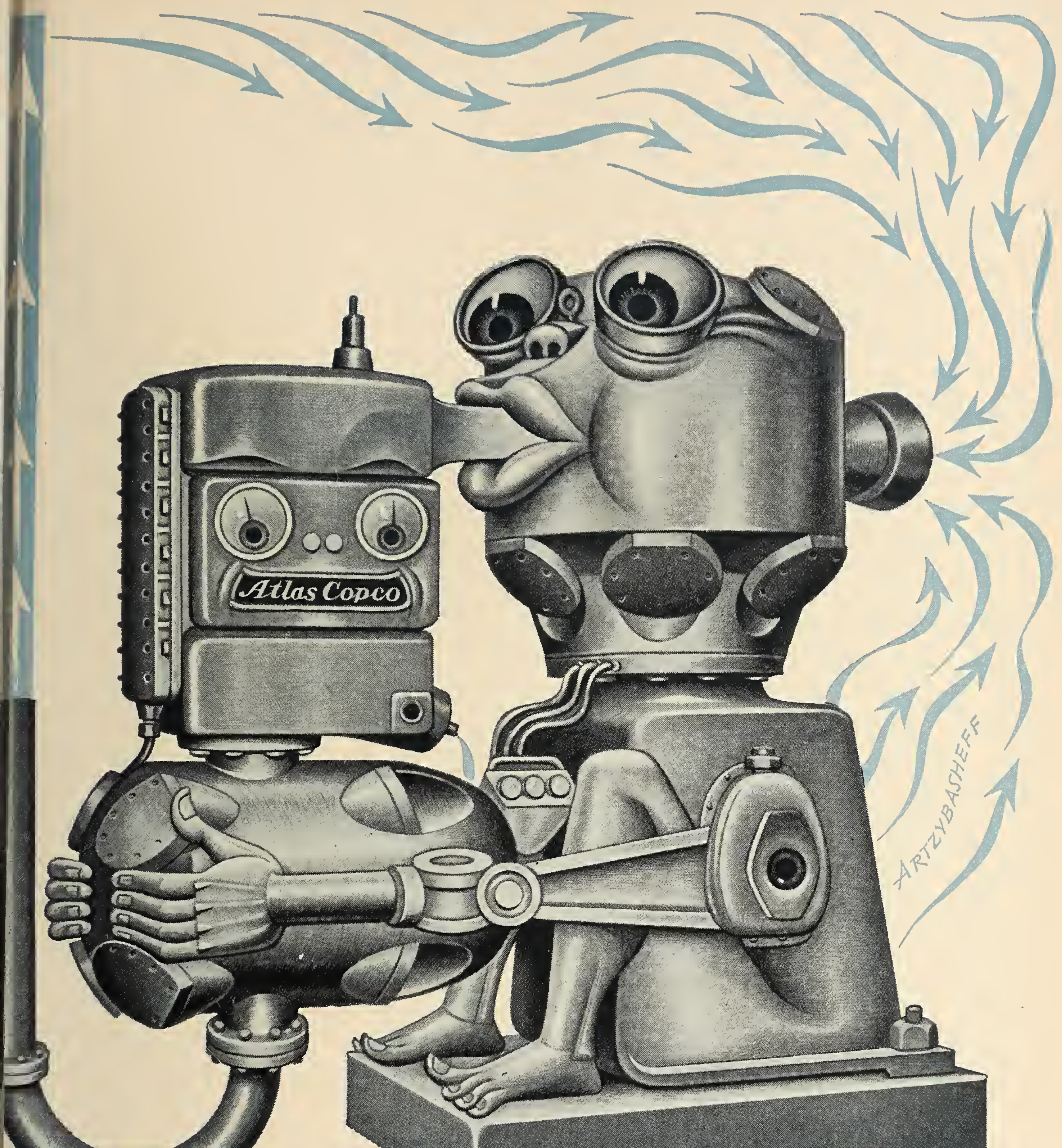
Information contained in this section has been obtained from press releases. Mention of products and services does not imply endorsement by the Institute.

CANADIAN GENERAL ELECTRIC has announced a new 72-page cutting tool catalogue featuring specifications and complete pricing information for cemented carbide inserts, blanks, brazed tools and cemented oxides. Copies are available by contacting the company at 1199 Lansdowne Avenue, Toronto 4, Ont.

THE FORMATION of a new company, Electrovert Manufacturing Company Limited, with administrative headquarters and manufacturing facilities in Montreal has been announced. The company will manufacture automatic wave-soldering equipment for the electronic industry, as well as computers, radios, television sets and hearing aids.

PLANS FOR THE CONSTRUCTION of a plant to manufacture Sakrete products have been announced by the Flintkote Company of Canada Limited. The site of the plant will be Flintkote's Oak Park Gravel Plant at Brantford, Ont. Sakrete is the trade name of a line of ready-to-use products, including a dry concrete mix, sand mix, mortar mix and plaster mix, designed for the do-it-yourself market.

(Continued on page 112)


Atlas Copco
ARTZYBASHEFF

(Continued from page 88)

ied by Adam Sandilands, Chairman of the Branch, and W. Rutherford. At the luncheon sponsored by the Executive Members of the Branch, Mr. Sandilands tabled a resolution made by the Executive concerning the proposed Confederation under discussion between the Institute and the Canadian Council of Professional Engineers until after the report of the Confederation Commission. Dr. Ballard explained in detail the complications and great differences of opinion expressed by groups in different parts of Canada. He confirmed that negotiations were proceeding and took note of the desires of the Branch on this matter.

During the afternoon, Dr. Ballard and Counsellor Professor S. Sinclair visited the University Campus to address the Engineering Students. That evening, the Branch held a meeting at the Corona Hotel. The Honorable Gordon Taylor, Minister of Highways for the Province of Alberta greeted Dr. Ballard who pointed out the importance of engineers in the economy of Alberta.

Dr. George Govier, Dean of the Engineering Faculty and Acting Chairman of the Oil and Gas Conservation Board, introduced Dr. Ballard. In his address to the Branch, Dr. Ballard reviewed number of the problems confronting tl Institute. He said that his visits to tl various Branches have two purpose they help headquarters to understand tl requirements and aims of the Branche and at the same time give him the o portunity to inform the Branches current business being handled by tl Institute Headquarters.

Regarding Confederation, Dr. Ballar said that the Institute has done co siderably more towards a conclusion th other Associations. He did not wish th to be interpreted that other societies ha been obstructive. He explained that tl Canadian Council of Professional E gineers is having many problems fro its Provincial Associations. He illustrate this by giving examples in Quebec an Ontario. So far, the Institute has bee unable to obtain a satisfactory rep from the C.C.P.E. on what it intends t do about Confederation. Opinions on th matter vary considerably across Canad and they tend to be violently oppose Dr. Ballard believes that it is very doub ful that the reports as put forward i their present forms could be adopte and there seemed to be no doubt in hi mind that some amendments would b necessary in order to accommodate th opinions of all concerned.

Dr. Ballard mentioned that the budge was not balanced, and he said that thi was not due to the cost of publishing th Engineering Journal. He stated that th fees would have to be increased in orde to carry on satisfactorily, and as a resul of other discussions, he was convince that the Institute must have better rep resentation in the Council from mor parts of Canada. An increase in fee would enable this to be achieved.

After a lively question and answe period during which a number of ques tions on Confederation and the Librar were discussed, B. Ellis, Vice-Presiden of the Branch thanked Dr. Ballard fo his talk.

Dr. Ballard then made the presentatio of the Engineering Institute Prize t Malcolm Wilson, the best Engineerin student at the University of Alberta.

One of the members of the Branch' Executive, W. Rutherford was to take a appointment in Ottawa with the Nationa Energy Board, and best wishes were extended to him on behalf of the member by A. Sandilands.

Estevan Section

O. P. Lesiuk, M.E.I.C.
Correspondent

"Drilling and Completion Problem in Pincher Creek Area, Alberta" was th title of the talk given by Doug Church to the members of the Branch at thei March 5 meeting. Mr. Church is Area Engineer for B.A. Oil's Producing Department in Estevan.

In his talk, Mr. Church dealt with the problems initially encountered in drilling in the foothills around Pinche Creek. He described how certain techniques lowered the cost of drilling and completing a well from more than $750,000 to less than $333,000. The

echniques used were unique to that rea, and special steel alloys were re- uired to deal with the great quantities f sour gas found in the Pincher Creek- Vaterton area.

A report on the annual A.P.E.S. meet- ng was given by Branch Chairman G. Irsenbach.

An executive meeting was held March at which time it was decided that budget would be set up to ensure unds for the annual scholarship. The cholarship committee was to decide nethods for raising funds. The program onvenor was to form a committee to ssist in obtaining suitable speakers for he May and June general meetings. The peaker for May and June would be one who would explain the technicians affiliation with A.P.E.S.

Estevan Collegiate requested that a peaker be secured to talk to the stu- dents on the career possibilities of engi- neers and technicians. The speaker could also explain the various aspects of af- filiation with the A.P.E.S.

Halifax

D. E. Rudolph, M.E.I.C.
Correspondent

The annual students' meeting of the Branch took place March 5 at a buffet supper at the Jubilee Boat Club. A panel discussion followed the buffet. G. H. Dunphy, M.E.I.C. was the moder- ator. The topic was "What is expected of the new engineering graduate?" Panelists were; Lt. Col. P. C. Ahern, M.E.I.C., J. Jay, M.E.I.C., C. F. MacNeil, M.E.I.C. and D. E. Sawyer. The panelists discussed the importance of scholastic ability, the question of whether an engi- neer must eventually become a part of management, the future of engineering, what industry expects from an engineer and whether an engineer should join the Engineering Institute of Canada or a provincial association. The questions from Branch members and from the students present, and the comments from the prominent panel, demonstrated a keen interest in the subject. Some new ideas were expressed on these not-so-new problems. Program arrangements were by F. C. O'Neill and his committee.

Newfoundland

Anthony O. Nemec, M.E.I.C.
Correspondent

The Branch's annual public speaking contest was held March 22 at Memorial University. Throughout the year the Engineering Department of the uni- versity conducts weekly seminars during which second and third year students give talks. The faculty then selects the three top speakers from these seminars, and they become the contestants for the Branch's public speaking prize.

William Kennedy, a fourth year stu- dent was this year's winner. The title of his speech was "Engineering Education in the Soviet Union". Mr. Kennedy plans to attend the Nova Scotia Technical Col- lege to obtain a degree in electrical engineering. Other contestants were Leblan Davis and John Neville, both third year students at Memorial. Mr. Davis spoke on the charge of the light brigade. The title of his talk was "The Reason Why". Mr. Neville spoke on the "Frost Damage to our Highways".

All members who attended were im- pressed with the high calibre of the entire program. A lunch was served after the meeting.

The Branch announced its plans for a field trip to the Golden Eagle Oil Re- finery at Holyroad on April 14.

Nipissing and Upper Ottawa

J. S. Cooper, M.E.I.C.
Correspondent

The monthly dinner meeting of the Branch was held at the Golden Dragon Restaurant, Ferris, on March 7. This was the annual students' night when members sponsored students from the high schools who had expressed inter- est in engineering careers. Students were present from North Bay, Temiskaming and Sturgeon Falls.

Branch Chairman R. A. Booy pre- sided at this meeting. The guest speaker was Richard L. Beck, of the Civilian Atomic Power Department of Canadian General Electric. He was in- troduced by G. M. Goodreid. Mr. Beck's talk, "The Fuel Cell", dealt with the direct conversion of heat or fuel to electrical energy, the need for such

(Continued on page 100)

(Continued from page 99)

methods, and the accomplishments to date in this field. Mr. Beck said that research was spurred because the world's supply of carbonaceous fuels was limited and greater efficiency was necessary, space flights required equipment with no moving parts and military considerations called for equipment that was light, portable and silent. With the aid of slides, Mr. Beck described three alternative ways to develop power from heat, the magnetohydro dynamic, thermoelectric and thermionic methods. He then dealt more fully with the fuel cell which a method of converting fuel directly to electric power and is more advanced in development than the others. Like the ordinary battery, the fuel cell is a source of low voltage direct current, but unlike the battery, the fuel cell does not store energy, it merely converts it. It can be described as an electrochemical device in which energy of reaction between a conventional fuel and oxygen is converted directly and usefully into low voltage direct current electrical energy. Some practical applications have already been made using hydrogen as the fuel to power portable radio transmitters and receivers.

Oakville

E. C. Smith, M.E.I.C.
Correspondent

At a meeting in the Royal Oak Hotel, Oakville, on February 22, the Branch members heard a talk on the Douglas Point Nuclear Power Project, given by R. B. V. Simmons of Atomic Energy of Canada Limited. The Project is now under construction near Kincardine, Ont., on east shore of Lake Huron, and Mr. Simmons, on loan to the A.E.C.L. from Canadian Westinghouse, is safety engineer for the project.

He reviewed the factors involved in selection of the site, and the economic background of the Project. He described the station and the reactor with its associated systems. The reasons behind the design and layout were discussed. Cross-feed fuelling, moderator dumping and other special features of the CANDU (Canadian Denterium Uranium) type of natural uranium fuelled, heavy water cooled reactor were covered. Many entirely new design problems were being met and overcome. The system of underwater fuel storage was described.

Mr. Simmons said that it is hoped this purely Canadian type of reactor would provide an answer to the need for economic nuclear power. The operation of the CANDU reactor would be demonstrated by the 20 megawatt (electric) N.P.D. reactor shortly to go into service at Ralphton, Ont. The full scale Douglas Point Project, of 200 MW (E) capacity is scheduled to go on the line in 1965.

Prince Edward Island

Alex Scott was the guest speaker at a meeting held February 28 at the Charlottetown Hotel. He dealt with seve[ral] topics including the difficulties met d[uring] the construction of the Hillsborou[gh] River Bridge; some phases of the co[n]struction of the Angus L. MacDon[ald] Suspension Bridge at Halifax, and so[me] features of the proposed P.E.I. Cau[se]way.

It was agreed that the Department [of] Mines and Technical Surveys in Otta[wa] should clarify some of the queries whi[ch] have developed regarding the different[ial] in the water levels on each side of t[he] proposed causeway. According to Ma[jor] General Young, this differential may [be] as much as seven or eight feet. This [is] contradictory to the information fou[nd] in the tide tables issued annually by t[he] Department. These tables state that tid[es] from the Atlantic enter the Gulf throu[gh] Cabot Straits, divide near the Magdal[en] Islands, with one portion entering t[he] end of the Northumberland Strait, t[he] other entering the south end, and bo[th] tides intermingling near the area of t[he] proposed causeway with a similar tid[al] range in each case.

The members were disturbed by t[he] announcement that the idea of providi[ng] openings in the causeway was being co[n]sidered. If there will be a difference [in] tide levels, the provision of openin[gs] would cause excessive rip tides whi[ch] might cause damage to the causew[ay] even if there is to be only a slig[ht] differential. The members felt that som[e] clarification and more detail technic[al] information is necessary.

University of British Columbia

J. A. Simpson, S.E.I.C.
Correspondent

Eighteen members and 22 student[s] visited the site of the forthcoming Seattl[e] World Fair on February 24 to tour th[e] construction of the fairgounds. M[r.] Christianson, Chief Engineer, Centur[y] 21, arranged the tour and provided th[e] group with three guides. The tour di[d] not provide the teehnical informatio[n] potentially available from such a project[;] however, the monorail, the space needl[e] and the large number of buildings re[cently] constructed in a relatively smal[l] area proved very impressive.

Sixty members and 40 students at[tended] a Student's Night held March [..] at Oscar's Steak House. After a smor[gasbord] dinner, three students presente[d] papers in the annual students' pape[r] competition. Dick Zingle spoke on wate[r] purification, in particular, the extractio[n] of pure water from sea water. Pau[l] Picha spoke on pre-consolidation of pea[t] in road construction, and Roy va[n] Ryswyk on the filling and draining o[f] glacier lakes. First prize was won b[y] Mr. Zingle.

The evening ended with a lively pane[l] discussion which, judging by the excellent response and the sometimes heate[d] retorts, was a success and proved tha[t] all engineers are not as apathetic as one of the panelists suggested.

Jniversity of Vestern Ontario

'avid Fader, S.E.I.C.
orrespondent

G. Chorley, an associate in the con- ilting firm of M. M. Dillon & Co., was ie guest speaker at the March 13 eeting. In his talk entitled, "Me- ianical Engineering in a Consulting irm", Mr. Chorley gave a general re- ime of heating, plumbing, refrigera- on, air-conditioning and the outside rainage of buildings, mentioning several)des and guidebooks as references. He ealt also with building fire protection id sound attenuation in the ductwork. lans for the new mens' residence were iown and discussed. Many questions 'ere answered from the very informa- ve talk. Mr. Chorley was thanked by . Dunsmoor.

EIC

Beaver Bill says:

You know, John, I was surprised to hear you remark last night you were disappointed to see the small turnout at your Branch meeting the other night when Al Electric spoke on a subject you considered to be outstanding. I have no doubt it was outstanding because Al Electric is one of those engineer-scientists who is helping to push back the frontiers of knowledge, and make know-how available. He is playing a vital role in developing new elements of our economy. This is sometimes the case, John.

Often an expert does not prove to be a "crowd puller". On the other hand, if the people who participated in the meeting, and particularly in the discussion, grasped something of the speaker's vision, then it was a first-rate meeting. It is the quality of participation which counts, not the numbers.

I'll be looking forward to seeing you the next time you are in town.

Yours sincerely,

• Library Notes

(Continued from page 90)

*SYMPOSIUM ON CURRENT RESEARCH ON MOTOR GASOLINE WHICH MAY AFFECT FUTURE SPECIFICATIONS.

A review of current trends in the characteristics of motor gasoline is presented in this symposium. Various sections deal with the combustion characteristics and properties of motor gasoline, gasoline composition, and engine requirements. (Philadelphia, American Society for Testing and Materials, 1961. 104 p., $3.00 s.t.p. 298.)

FRASER'S CANADIAN TRADE DIRECTORY, 1961.

As usual, the Trade Directory is a mine of information. Its main section is a classified list of products, together with their manufacturers and distributors in Canada. Also included are lists of Canadian manufacturers, trade names, and U.S., British and foreign manufacturers and their Canadian agents. The market data section includes information on trade commissioners, Chambers of Commerce, banks, central power stations, public utilities, and cities and towns in Canada with a population of over 2000. (Montreal, Fraser, 1961. 1876 p., $12:50.)

MANAGEMENT GUIDE TO EFFECTIVE COMMUNICATION IN BUSINESS.

The ability to communicate is vital t those in business, but the art of reall effective communication is possessed b all too few.

This brief "guide" considers both or and written communications, with th emphasis on the former. The authors dis cuss the goals of communication, th keys to effective speaking, and the dif ferences in technique required for speak ing to groups and to individuals. Th second part of the book contains sugges tions for improving written communica tions, for in this field, the authors stat "any business men are still in the smoke signal stage." (B. T. Lewis and W. W Pearson. New York, Rider, 1961. 57 p. $1.25.)

DESIGN OF FISHWAYS AND OTHER FISH FACILITIES.

Although fishways have existed fo more than 300 years, it is only in mor recent times that any real research ha been done on the problems involved This text provides information on th fundamentals of fishway design an location, and water control. The autho is the Chief Engineer of the Departmen of Fisheries on the Pacific Coast, an much of his book is based on the practices there. Fishways at natural obstructions and fishways at dams are considered in detail, and other chapter cover fish locks, fish elevators, counting fences, barrier dams, fish screens and artificial spawning channels. Appendice cover methods of capturing salmon, and the hydraulics involved in the design of fishways. (C. H. Clay. Ottawa, Department of Fisheries, 1961. 301 p. $5.00. Buy from Queen's Printer, cat. no. Fs 31-1961/1.)

*THE APPLIED SCIENCE OF RUBBER.

A practical, comprehensive review of modern rubber technology. Written by persons with extensive industrial experience, the chapters cover natural and synthetic latices; the chemistry and structure of natural rubber; synthetic rubber; reclaimed rubber; processing, compounding, and reinforcement; elasticity and dynamic properties of rubbers; testing of rubber and finished products; the fundamentals and technology of ebonite; vulcanization; and rubber aging. (W. J. S. Naunton. London, Edward Arnold, 1961. 1191p., £8.8.0)

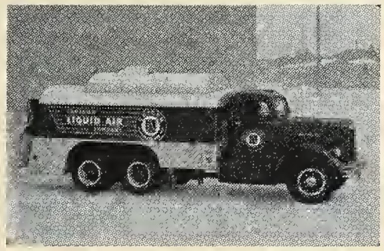
*EINFUHRUNG IN DIE KONTINUUMS-MECANIK.

This introduction to the mechanics of continua is intended as a preliminary to more advanced and specialized treatments of hydrodynamics, gas dynamics, elasticity and plasticity. It presents the fundamentals of tensor calculus, and the mathematical representation of states of motion and stress, ideal and viscous liquids, ideal plastic and visoplastic materials, and deformation. Review problems are provided in an appendix. (William Prager. Basel, Birkhäuser Verlag, 1961. 228p., SFr. 32.50.)

(Continued on page 106)

GIANT FLAGSHIP OF LIQUID AIR'S TRANS-CONTINENTAL GAS DISTRIBUTION FLEET

450,000 cu. ft. capacity tank trailer.



Liquid oxygen-carrying tanker for supplying bulk installations.

Typical L.A. service-supply truck.

GOLDEN ANNIVERSARY LIQUID AIR 1911 · 1961

The 1,700,000 cu. ft. capacity of Liquid Air's mammoth size railroad vacuum type tank cars would fill nearly 7000 standard oxygen cylinders. Canadian Liquid Air has two of these giants in operation, the largest of their type in the world and the only ones in Canada. These and our other tank cars are part of our nationwide distribution network of rail and road carriers bringing vital gases to industries and hospitals across Canada. With Liquid Air plants in every industrial center, supported by 700 L.A. dealers, stores, branch offices and depots, users of L.A. gases from coast to coast can depend on a ready supply, regardless of their location or requirements.

OXYGEN • ACETYLENE
HYDROGEN • ARGON • NITROGEN
OTHER INDUSTRIAL GASES
MEDICAL GASES AND MIXTURES
by direct pipeline, in bulk or in cylinders
TECHNICAL SERVICES

Canadian LIQUID AIR Company LIMITED

700 supply points throughout Canada

• Library Notes

(Continued from page 102)

***PILE FOUNDATIONS, 2nd ed.**

The theory, design, installation, maintenance, and repair of pile foundations are presented. In this edition the subjects of ship impact and wave forces on piled wharves and jetties have been considerably expanded. Design charts have been added to make information in this area conveniently available. The chapter on soil solidification has been brought up to date, standard specifications have been revised to current issues and new ones have been included, and the sections on drilled piles and caissons have been rewritten. (R. D. Chellis. Toronto, McGraw-Hill, 1961. 704p., $18.50.)

***DYAMIC OPTIMIZATION AND CONTROL.**

The dynamic-system control problem is viewed as the proper manipulation of plant inputs to optimize plant performance. Methods are described for obtaining a control law that specifies optimum plant inputs as a function of measured system state and the available statistical data on plant disturbances. The computation of solutions for such practical problems as vehicle stabilization, trajectory control, chemical process control, and inventory control is demonstrated, and it is explained how spatial analog computers can be applied as optimizing controllers. (Walerian Kipiniak. New York, Wiley, 1961. 233p., $4.95.)

A FIVE-ATTRIBUTE SYSTEM OF DESCRIBING APPEARANCE.

An extension of the three-attribute system of colour description, a major contribution to the science of describing engineering materials. This revised version of a paper published some 25 years ago was prepared at the request of the ASTM Committee on Aluminum Finishes. In this system, the nonshape, nontextural aspects of visual appearance are classified by four modes of appearance, aperture, illuminant, volume and surface. (D. B. Judd. Philadelphia, American Society for Testing and Materials, 1961. 15p., $1.00. s.t.p. 297.)

BIBLIOGRAPHY AND ABSTRACTS ON ELECTRICAL CONTACTS; 1960 SUPPLEMENT.

187 abstracts of papers and books, the majority of which were published in 1960. All aspects of electrical contacts and devices which utilize electrical contracts are covered. (Philadelphia, American Society for Testing and Materials, 1961. 47p., $4.50. s.t.p. 56-0.)

DIRECTORY OF DIRECTORS, 1961.

An alphabetical listing of almost eleven thousand Canadian directors and company officials, showing their executive positions and directorships. Also listed are 2300 Canadian companies with their boards of directors and executive officers. A most useful directory. (Toronto, Maclean-Hunter, 1961. 617p., $15.00.)

STANDARDS REFRIGERATION AND AIR CONDITIONING QUESTIONS AND ANSWERS.

Intended primarily for those engage[d] in operating, servicing and installing re[-]frigerating and air conditioning equip[-]ment, this text will also prove useful t[o] students and many others. The questions are divided by subject, and cover every[-]thing from fundamentals to the latest de[-]velopments in absorption systems, and cryogenics. The topics covered includ[e] refrigerants, compressors, condensers, controls, piping, defrosting, motors an[d] drives, cooling towers, cooling water an[d] safety. A useful section covers licens[e] requirements for refrigeration and ai[r] conditioning engineers in Canada an[d] the United States. (S. M. Elonka and Q.W. Minich. Toronto, McGraw, 1961. 253p., $7.30.)

INTERNATIONAL AND METRIC UNITS OF MEASUREMENT.

A report on the most recent change[s] in standard units of measurement, made by international agreement, including the new definition of the meter, the tesla and the international pound. Units of measurement are included for angular measure, area, atomic energy units, density and concentration, electrical units, energy, flow, force, length, magnetic units, mass, power, pressure, time, velocity and volume. Much of the data i[s] given in tabular form. A detailed index increases the value of this very useful book. (M. H. Green. New York, Chemical Publishing, 1961. 116p., $6.00.)

ATOMS AND MEN.

The author, an internationally known atomic physicist, has written a sensitive book on the usefulness of science, and the conditions it requires in order to thrive. He writes of the excitement of discovery, of nuclear research centres in the United States, of international scientific meetings, the place of France in research, the French technical education system, and finally, the place of present-day scientific knowledge in the Christian faith. (Louis Leprince-Ringuet. Toronto, University Press, 1961. 118p., $3.00.)

ARMATURES AND FIELD COILS.

Although small electric motors are in such wide general use, comparatively little has been written about armatures and field coils. This volume deals with armatures of up to 2 h.p. in common use, and covers both lap and wave winding, insulation, various types of commutator and connections, and armature testing. Field systems are also covered in detail. Different types of coil are discussed and winding methods described, as are the various tests to use. A final chapter is concerned with mechanical design and construction of motors. A series of articles which appeared in The Electrical Times form the basis of this volume. (Karl Wilkinson. London, Spon, 1961. 224p., 35/-.)

ROCEEDINGS OF THE 23rd AMERICAN OWER CONFERENCE, 1961.

Sponsored by the Illinois Institute of echnology and other universities and ocieties, the Conference aims to provide a forum for the discussion of problem and the exchange of information. The papers presented emphasize the ractical rather than the theoretical point f view.

The various sessions covered nuclear ower plants; central stations, boilers, enerators, etc.; power plant auxiliaries; tmospheric pollution; fuels; steam enerators; personnel training; the economics of plant operation; industrial ater technology; peaking; high-voltage ransmission; automation; system planing and operation, electric distribution; pparatus. (Chicago, Illinois Institute of echnology, 1961. 953p., $10.00.)

WENTY-YEAR ATMOSPHERIC CORROSION NVESTIGATION OF ZINC-COATED AND UNOATED WIRE AND WIRE PRODUCTS.

The results of research commenced n 1936, and still continuing, as part of programme to evaluate the atmosheric-corrosion resistance of various netallic coatings and treatments of wire. The investigation established, among ther things, that the life of a zincoated wire is proportional to the weight f coating; that the time rate of loss of inc is linear; that the corrosion rate of inc coating is independent of the nethod of coating; that strengths of opper and lead-coated wires are not ignificantly affected after 20 years. F. M. Reinhart. Philadelphia, American Society for Testing and Materials, 961. 141 p., $5.50.)

TABLES NUMERIQUES DE FONCTIONS ELEMENTAIRES.

The values given in these tables were btained on an electronic calculator. The ables, which are intended primarily for se by under-graduates, cover elemenary functions: square and cube roots; xponentials and hyperbolic functions Napierian and decimal logarithms; trigonometric functions; radians; converion of angles; mathematical constants. J. Laborde. Paris, Dunod, 1961. 149p., 12 NF.)

PRINCIPLES DE STATISTIQUE MATHEMATIQUE.

Intended primarily for students in psychology and the humanities, the text gives the general ideas of logical order and the calculation of probabilities, by the use of concrete examples. Also covered are the binomial theory, and their relation to the theories of Laplace and Poisson. The author shows how these theories and ideas can be applied to such things as the calculation of parameters, comparing two samples, etc. (A. Tortrat. Paris, Dunod, 1961. 163p., 16 NF.)

MESURES ELECTRIQUES ET ELECTRONIQUES.

In this volume the author presents an over-all view of electric and electronic measurements, and discusses the different measuring instruments and methods of measuring.

After introductory chapters on electric units, the principles of measurement, the various types of electric motor, and the quality and accuracy of measurements, the author discusses the use of electronics in measuring instruments. The main part of the book is concerned with instruments for the various measurements: voltage, and its sources; intensities; resistance; impedance; quantities of electricity; magnetic induction; frequency; displacement; trransmission of current; recorders; the cathode-ray oscilloscope. (Jacques Thurin. Paris, Eyrolles, 1961. 431p., 54.55 NF.)

PROTECTION PAR PROJECTION AU PISTOLET.

Intended primarily for the corrosion expert, this volume provides a review of the different methods of the use of a spray gun, and of the preparation of the surfaces to be protected. After an introductory chapter on the mechanics of corrosion, the author discusses the principles of coating by metallizing, the different types of coating to be used against wet and dry corrosion, and for the protection of plastics used in contact with acid, and of refractories. The text of the French standard on the subject is included, as well as the numbers of the relevant CSA, BSI and ASTM ones. (P. Orlowski and J. Cauchetier. Paris, Dunod, 1961. 93p., 14 NF.)

TRAITE THEORIQUE ET PRATIQUE DES ENGRENAGES, *t.*2., 3. éd.

In this second volume, M. Henriot considers the problems concerned with the manufacture and assembly of gears. The first chapters cover the various types of gear teeth and their manufacture. Other chapters deal with worm gears; grinding of gears, parallel and conical; shaving of gear teeth; metrology, lubrication; heat treatment; control. As with all M. Henriot's books, this contains a wealth of information, and is well illustrated. (G. Henriot. Paris, Dunod, 1961. 543p., 78 NF.)

*ENERGY CONVERSION FOR SPACE POWER.

This book is volume III in the American Rocket Society's Progress in Astronautics and Rocketry, and is the first of two volumes of papers from the ARS Space Power Systems Conference held with the cooperation of AIEE in September 1960. The papers are concerned with the scientific and engineering principles involved in the conversion of various types of energy into electrical energy. They deal with thermoelectricity, thermionics, photovoltaic cells, electrochemical cells, dynamic engines, magnetohydro dynamics, and electrostatic generators. (N. W. Snyder. New York, Academic, 1961. 779p., $7.25.)

(Continued on page 108)

Library Notes

(Continued from page 107)

*PLANT LAYOUT: FACTORS, PRINCIPLES, AND TECHNIQUES.

The problem of preparing a plant layout, and the collection of technical data necessary for making preliminary as well as final decisions are discussed. Eight sections cover the concept of plant layout, preliminary analysis, materials handling, layout patterns, the provision of services, office layout, the presentation of the layout, and plant location.

Appendices describe quantitative evaluation techniques. (Ruddell Reed. Homewood, Ill., Irwin, 1961. 459p., $10.65.)

*SCIENTIFIC BASIS OF ELECTRICAL ENGINEERING.

A single broad conceptual foundation is presented, on the basis of which the reader can proceed to the specialized study of energy conversion, electronics, circuits, transmission, and radiation. The authors develop the basic theory of electrical phenomena beginning with electrostatics in vacuum and progressing to general electrodynamic relations. Then the atomic structure of matter is discussed to establish a basis for interpreting the macroscopic electromagnetic effects of materials in electrical systems. Finally, the reader is introduced to the general problem of applying electrical theory to the analysis of physical systems. (J. M. Ham and G. R. Slemon, New York, Wiley, 1961. 816p., $9.95.)

MODERN CIVIL ENGINEERING PRACTICE.

A review of current civil engineering practice, with the emphasis on British methods and achievements. The various chapters have been written by experts, and the general editor is Rolt Hammond, well known for his books on engineering topics.

Achievements and practices in all aspects of civil engineering are discussed: the nuclear programme; road construction; bridges; railroads; tunnelling; water supply and irrigation; hydroelectric power; dam construction; photogrammetry. There are also interesting and useful chapters on organisation and policy in civil engineering contracts; the achievements of British civil engineers abroad; the development of mechanical equipment; safety on the construction site; and fire protection. There is also some information on the future prospects in civil engineering, and civil engineering as a career. (Ed. by Rolt Hammond. London, Newnes, 1961. 493p., £4.)

INTERNATIONAL MINERAL PROCESSING CONGRESS, 1960.

The proceedings of the fifth inte national congress on mineral dressin held in London in 1960, this volum contains the text of the 52 papers pre sented, as well as the discussion the aroused. The papers were divided int nine sessions and covered: comminu tion; classification and thickening; flota tion research; flotation practice; gravit and dense media separation; magneti and electrical separation, sorting; chemi cal processing; process study; contro and testing.

The papers are all in English, wit abstracts in French, German and Rus sian. They were presented by expert from all over the world, including Can ada. The volume is well illustrated bibliographies are included, as is a index. (London, Institution of Minin and Metallurgy, New York, Heinman 1960. 1118p., $20.00)

*PH MEASUREMENT AND TITRATION.

Intended to be primarily practical i nature, this volume introduces theo retical concepts only where they ar closely relevant to practical goals. Th main emphasis is on e.m.f. methods o pH measurement, although colorimetri

(Continued on page 111)

Library Notes

(*Continued from page 108*)

echniques are discussed. The topics overed include buffer solutions; pH neasuring electrodes; reference elecrodes; liquid junctions; E.M.F.-temerature characteristics of pH cells; laoratory pH measurements with glass lectrode; industrial pH measurements nd automatic pH control; laboratory pH itrations; non-aqueous acid-base titraions; and automatic pH titrations. There is an extensive chapter on pH neasuring instruments. (G. Mattock. Salt, Brett-Macmillan, 1961. 406p., $14.50.)

FLOW MEASUREMENT AND METERS, 2nd ed.

Since the publication of the first ediion of this book in 1949, there have been considerable advances in the techiques of flow measurement. In this edition, new material has been added on differential pressure meters, the electromagnetic flow meter, ultrasonic flow meters on which research is in progress, transducers, and flow summation.

Information on the older types of flow meter has been retained, as they are still of interest, and the basic principles involved are still valid. The topics covered include mechanical flow meters, shunt flow meters, variable-aperture flow meters, open-channel flow meters, riverflow gauging, and telemetering.

The book presents a theoretical and practical review of the present state of the science of measurement of the flow of liquids and gases, through open or closed channels, under industrial conditions. (A. Linford. London, Spon, 1961. 430p., 70/-.)

PLANT PRODUCTION CONTROL, 3rd ed.

Modernized and largely rewritten, this edition features a new arrangement of chapters grouped to show first contributing functions and then actual functions for controlling the flow of materials through any type of manufacturing establishment. New chapters have been added on the use of digital computers in production control, operations research and data automation, and cycle scheduling. The latter is a carefully planned mathematical procedure for scheduling the setups of machining operations for each order of parts which are to be included in the cycle program. Also included is a suggested outline for installing a production control system. (C. A. Koepke. New York, Wiley, 1961. 373 p., $11.75.)

NEW BOOKS!

Each month, the Library issues a list of all the books, reports, pamphlets, standards, etc., added to the loan collection during the previous month. Write to the Librarian and ask to have your name added to the mailing list!

*HEAT-TRANSFER CALCULATIONS BY FINITE DIFFERENCES.

The practicing engineer has, in principle, a choice between analytical, analog, and finite-difference methods for the solution of problems in temperature fields. However, in many instances, a finite-difference approach will lead to economical and valid computer programs. A reliable and comprehensive guide to finite-difference methods for heat-transfer calculations is presented, and is illustrated by a series of examples covering a wide variety of applications. (G. M. Dusinberre. Scranton, International Textbook, 1961. 293p., $12.75.)

*THEORY OF MARKOV PROCESSES.

Markov processes are rigorously defined, with particular emphasis on stationary processes, and a detailed analysis of problems pertaining to subprocesses of Markov processes is presented. The author also discusses the construction of Markov processes with given transition functions, the theory of strong Markov processes, and the boundedness and continuities of sample functions of Markov processes. A translation from the Russian. (E. B. Dynkin, Englewood $11.95.)

(*Continued on page 120*)

Developments

(Continued from page 96)

CRITERIA FOR JUDGING the quality of steel strapping are listed and explained in a 32-page booklet issued by the Canadian Steel Strapping Company of Scarborough, Ont. This free booklet, entitled "The Twelve Qualities of Steel Strapping", discusses the uniformly high strength, adequate elongation, uniform thickness and width, straightness, safe, smooth edges, amongst other specifications. Strapping terms are defined, photographs and drawings illustrate this very informative booklet.

NEWLY DESIGNED 230 KV I-T-E air switches, complete with insulators are available from I-T-E Circuit Breaker Canada Limited. Due to the use of aluminum, these switches are 27% lighter in weight than previous designs. A reduction in weight of the current carrying parts reduces the mechanical duty on the bearings and switeh bases, and this lighter duty on the components, in conjunction with a different design approach, makes possible a considerable weight reduction on the switch bases, bearings and gear box.

AN INDUSTRIAL DIESEL ENGINE has been introduced by Rolls-Royce of Canada Limited, The SF65 is an Aeravation of the existing Rolls-Royce 'C' range of four, six and eight cylinder engines. The new engine, rated in the 150 BHP category, is a 707 cubic inch, naturally aspired six-cylinder-in-line engine of five inch bore and six inch stroke. The SF65 is available in three forms: firstly, the basic fan to flywheel engine; secondly, the industrial engine with mounting feet and air cleaner; and thirdly, the complete radiator cooled uncowled power pack to suit a variety of requirements.

VICKERS-SPERRY OF CANADA, a Division of Vickers Incorporated, Sperry Rand Corporation, has announced a hydraulic power package featuring a vane-type double pump with 2000 p.s.i. capability. External pressure control valves provide the hi-lo pump combination, either large volume at low pressure, or high pressure at low volume. Adjustable pressure control, remote control, or automatic high-low pressure control are provided.

HI-LO EQUIPMENT (CANADA) LIMITED, makers of the "Canuck" Pallet Truck, has introduced the battery operated hydraulie lift truck to its line. This lift loads, unloads, stacks or moves anything up to 1500 lb. Equipped with a heavy duty 12 volt industrial battery and built-in charger with automatic overload protection, the cost of nightly recharging is only one cent. All models have foot-operated floor locks and safety flow control valves which regulate the lowering speed.

PRESSURE REDUCING VALVES precision engineered and produced by the James Morrison Brass Manufacturing Co. Ltd. are available. The valves feature closings against inlet pressures. Low pressure is unaffected by fluctuations in high pressure, and internal parts are removable while the valve is connected to the line. The valves are constructed of corrosion-resistant bronze with high tensils cast iron cover. A renewable Buna-N disc ensures tight closures and the diaphragm is Neoprene-reinforced for long life. The valve is designed for water, oil or air service.

A VERTICAL STROKING, heavy duty G-4 buffing lathe for mush type buffing operations on irregular shaped, recessed or contoured parts have been introduced by Canadian Hanson & Van Winkle Ltd., Montreal. The buffing lathe can be used with semi-automatic finishing machines for mush and slough buffing on parts such as automotive horn rings, die cast frames, brass plumbing components and die cast bezels.

A NEW VERSION of the Canadian Westinghouse Company's distribution apparatus catalogue has been announced. The 300-page catalogue contains complete design and application data about liquid filled distribution transformers, housings, regulators, filter presses and a.c. test sets. Other sections deal with underground service equipment, dry-type distribution transformers, lightning arresters, protective devices, capacitors and instrument transformers. A copy of catalogue H-55000 may be obtained by writing; Canadian Westinghouse Company, Distribution Apparatus Division, London, Ont.

TINY SILICON RECTIFIERS and larger selenium rectifiers of the same capacity have been introduced by Syntron (Canada) Limited. Both types come in a wide range of sizes and capacities for the electronics industry. The Syntron silicon rectifiers are produced with double vapor diffused junctions. They yield lower forward voltage drops and provide greater uniformity of reverse characteristics. Peak reverse voltage in some units approaches 200 volts. An extensive range of diodes from low to medium power types are available from the Canadian plant.

MAINTENANCE-FREE, LEAD-ACID BATTERIES have been developed by the Exide Industrial Division of the Electric Storage Battery Co. (Canada) Ltd. These batteries are produced in two basic types, one for use in portable power systems, the other for heavier stationary systems. They combine the advantages of power and rechargeability characteristic of wet-cell batteries, with the handling ease of dry-cell batteries. The portable, and the stationary types require no addition of water or acid throughout their service lives.

EIC

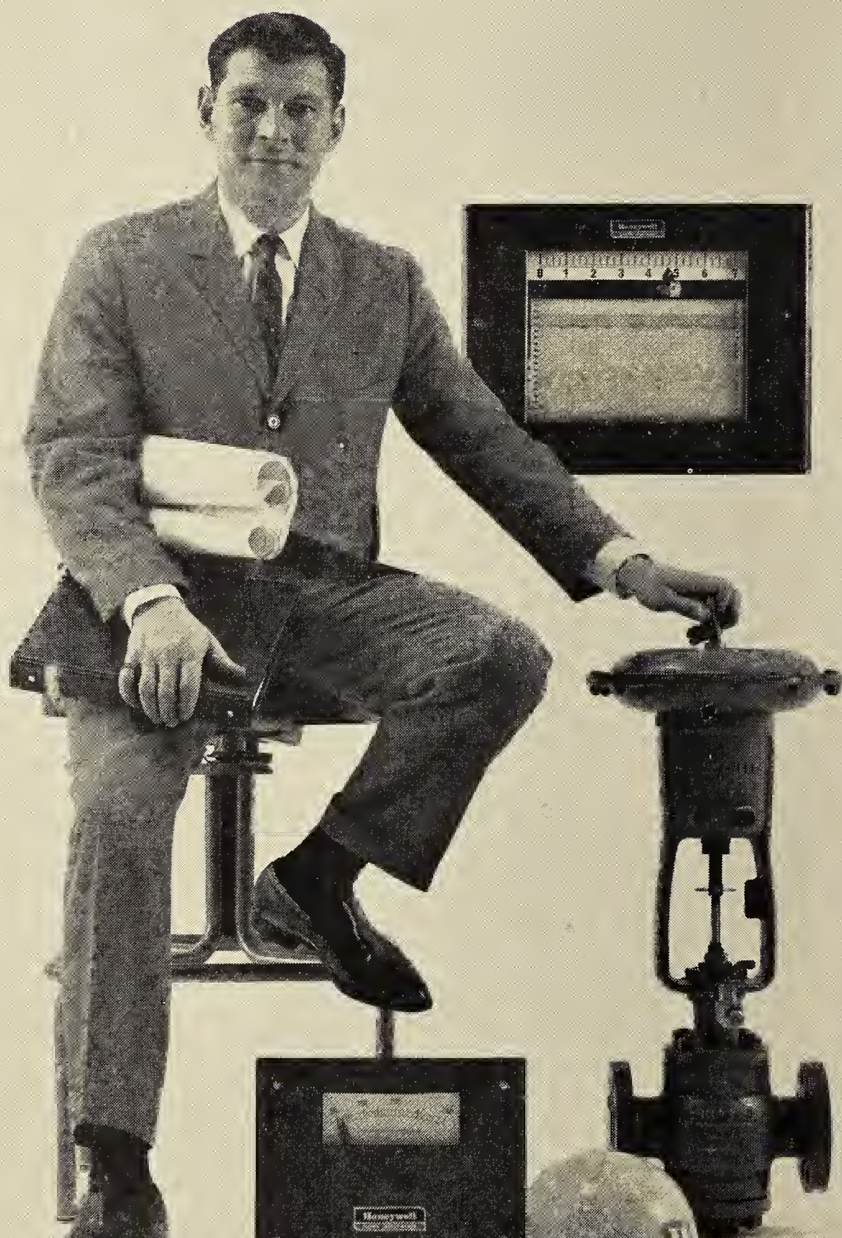
A HEAVY-DUTY TRACK DRILL, the BVB61RD has been introduced to the mining and construction industry by Atlas Copco Canada Ltd. The BBE51 rock drill mounted on the rig makes full use of the piston stroke, which is independently controlled to give the required percussive action on a special shank adapter. The piston-type air motor which transmits a very strong torque via a reduction gear to the drill chuck and shank adapter, also features this independent control.

A SPRAG CLUTCH designed for lightweight, high-speed over-running at 8000 r.p.m. and ambient temperatures up to 600° Fahrenheit is available from Renold N. Chains Canada Ltd., Montreal. Designed for 500% overload surges with a normal capacity of 55 hp. at 8000 r.p.m., this high-speed unit contains a full complement of retained sprags between two concentric races. To meet specific job requirements, this unit can be modified with special integral external gears, housings, splines, flanges or torque arms.

ATLAS COPCO CANADA LTD., has introduced a compact and relatively light unit for simple soil testing or for determining the depth of overburden over rock or other hard strata. The unit comprises the Borro sounding kit which is used in combination with Atlas Copco's self-contained motor drill, the Cobra. Sounding is carried out with 3 ft. 3 in., ⅞-in.-diameter extension rods fitted with two types of points. The Borro kit includes 20 extension rods together with chucks, couplings rod extractor, wrenches and a galvanized steel storage box.

CONSOLIDATED PAINT AND VARNISH (CANADA) LTD., Montreal, has announced a new line of both exterior and interior insecticide paints known as Kil-Sect. This paint contains Dichloro Diphenyl, an insecticide effective against most types of insects, yet safe to humans.

The economical way to buy instrumentation.



The economical way to buy instrumentation ...single source responsibility by Honeywell

there's a better way to buy instrumentation: assigning ource responsibility for the entire project to a qualified ent manufacturer. All in a single contract: from planning rough to start-up and post-installation maintenance.

ethod may have important advantages for you on your next . Instead of shopping for hardware, you can buy results.

instrumentation is so vital to the success of a project, so big a the job, that it warrants this special handling. When it does, n be major improvements in economy and efficiency. And spared the frustration, the buck-passing, the false starts and notions.

er for a moment the benefits you receive when you assign te instrument responsibility to Honeywell.

ANNING. Honeywell can make a valuable contribution to anning, along with your own engineering and production per- your consultants and equipment suppliers. You'll have avail- complete facilities of the world's largest organization for auto- measurement and control. Honeywell systems engineers have experience on a wide range of industrial processes. Added to roduct process knowledge this will assure you of a system ovides the results you want.

wish, you need only specify the critical control areas of your and the tolerances you require. Honeywell will assume full sibility for developing a control system to meet them.

well can shoulder as much of the load as you wish. You need to overload your present staff, or try to recruit scarce ists for a peak-load problem.

OCUREMENT. When Honeywell systems engineers assume esponsibility for a system, their primary concern becomes you the best possible system for your money, not selling you are. They're free to select the best device for each application other manufacturers as well as from Honeywell's own line of control equipment.

se none of the traditional privileges of an instrument buyer. But you gain a system that's produced by control specialists from start to finish.

There are valuable fringe benefits, too. Honeywell's assumption of undivided responsibility permits smoother integration of installation schedules. Your problems of ordering and accounting are simplified.

IN COST SAVINGS. There are certain obvious economies in dealing with a single supplier. You get them all when you assign single-source responsibility to Honeywell. But there are other economies, perhaps less obvious: by stressing results, not hardware, Honeywell can save you money in the planning of your system. And, in the long run, the most economical instrumentation system is the one that gives you the best results. You're sure of this when total responsibility is centralized.

IN INSTALLATION AND START-UP. As instrument systems become more complex, special installation problems arise: problems of timing, calibration, adjustment, check-out. They can best be handled by a fully-integrated, complete instrument service organization. Experienced Honeywell installation crews have installed some of Canada's most complex and difficult control installations. You're assured of on-schedule installations, thorough performance check-outs and smooth start-ups.

IN MAINTENANCE AND SERVICE. Honeywell's facilities are yours for as long as you need them. A variety of maintenance plans are available to keep your system always at top efficiency. If you wish, a full-time Honeywell maintenance crew will service your system, including all its non-Honeywell components. And Honeywell will maintain stocks of spare parts for all instrumentation supplied.

There are many new control projects where traditional buying practices are satisfactory. But there may be worthwhile benefits for you in the modern way to buy instrumentation. For further information, call your nearest Honeywell office or write Honeywell Controls Limited, *Industrial Products Group*, Toronto 17, Ontario.

oneywell

H HONEYWELL *First in Control*

1962 CONFERENCES

OF PARTICULAR INTEREST TO E. I. C. MEMBERS

Following is a tentative list of conferences to be held later this year either totally or partially under the sponsorship of the Institute. Further details will be carried on a regular basis in the pages of the Engineering Journal.

June 12 - 15	**E. I. C. Annual Meeting, Montreal**
August 24 - 25	**Baie Comeau Regional Conference**
September 12 - 14	**Edmonton Conference**
September 13 - 14	**Soil Mechanics Conference, Edmonton** **JOINT NRC - EIC**
October	**Chemical Engineering Conference, Sarnia** **JOINT CIC - EIC**
Autumn	**Newfoundland Regional Conference**

Steel gives design freedom

Y-shaped with clear spans. This is the Saskatchewan Power Corporation's head office building in Regina. There are no columns inside the wings of the building and each floor is a wide open space 43 ft. x 270 ft. You can build this way with steel—it simplifies interior partitioning and makes future changes easy.

Architects: Joseph Pettick, M.R.A.I.C.
Consultants: C.C. Parker, Whittaker & Co. Ltd.

Steel shows some of its qualities

Some of the basic qualities of steel as a ilding material are illustrated in this round- of recent projects from across the country. eel produces light, flexible structures and inherent qualities offer great scope to the aginative architect.

When evaluating structural framing ma- ials it is worth considering all the advan- ges offered by steel. Steel goes up fast to e an early return on invested capital and luces interest charges on construction loans. Lightweight framing keeps foundation costs down and the strength of the material permits large column free areas for better rentable floor space. Later alterations or additions are also easily effected and more economical to undertake when steel is used.

Dominion Bridge maintain design, fabrication and erection facilities in most of the major cities. Their sales and engineering departments are always available for discussion and to assist in any way they can.

124

Structural Steel Division **DOMINION BRIDGE**

DOMINION BRIDGE COMPANY — SIXTEEN PLANTS COAST-TO-COAST

Library Notes *(Continued from page 111)*

*EXPERIMENTAL METHODS IN COMBUSTION RESEARCH.

This loose-leaf manual is divided into two main sections: Instrumentation for the determination of fundamental data, which covers such topics as temperature, flow rate, flame propagation velocity, pressure measurement, and free radicals; and experimental set-ups for laboratory studies of the combustion process, which covers gaseous and vaporized fuels, turbulent flames, detonation, and liquid and solid propellants. Supplements are planned, especially on methods which may gain sudden emphasis. Titles appear in both English and French, although the text of any one paper is in only one of these languages. (Ed. by J. S. Surugue. New York, Pergamon, 1961. Various pagings. $15.00.)

*ENERGIEBILANZ UND RENTABILITAT VON HEIZKRAFTWERKEN.

A detailed treatment of energy balance calculations and the determination of earning capacity of thermal power plants. Both open and closed cycle gas turbines are considered as well as steam plants. Tables, charts, and energy-and heat-flow diagrams are included to illustrate or summarize the calculations. (Herbert Bachl. Berlin, Springer-Verlag, 1961. 78p., DM 18.00.)

*PLASTICITY AND CREEP OF METALS.

In this book on the deformation behaviour of metals under stress, emphasis has been placed on those aspects of interest to the design engineer, but the interests of the engineer or metallurgist dealing with fabrication and forming processes have also been kept in mind. Multiaxial stress as well as one-directional stresses are dealt with. (J. D. Lubahn and R. P. Felgar. New York, Wiley, 1961. 608p., $16.75.) EIC

CONSULTING SERVICES

EIC CERTIFICATE OF ADVERTISING MERIT

Northern Electric Company Limited wins the Monthly Award for the best advertisement in the February issue of The Journal with the same advertisement that won in October 1961. This serves as acknowledgment of the overwhelming impact of a 5-page insert, to say nothing of the quality of the advertisement itself.

The winning advertisement, headed, "Serving Canada's Power Utilities" was a 2-colour, 5-page insert — the odd page being accounted for by the fact that the first sheet of the insert had an extra half-page gatefold. The first page was a title page only; the gatefold featured the men and services behind the products, with the remaining three pages devoted to hard-sell copy and illustrations on a variety of Northern product lines. The second colour, blue (green was used in the October insertion) was effectively used in two shades to make a considerable mass of information appear more readable.

Advertising Manager for Northern Electric Company Limited is E. H. Woodley. The advertising is placed by the Montreal office of Foster Advertising Limited, Frank Thompson, account executive. Both men will receive a framed award certificate. Judging is done each month by a different panel of Journal readers across Canada, with nominations requested on the basis of ACCURACY — INFORMATION — ATTRACTION.

INDEX TO ADVERTISERS

MAY 1962

PUBLICATION OFFICES: The Engineering Institute of Canada, 2050 Mansfield Street, Montreal 2, Quebec, Canada.

Association of Consulting Engineers of Canada Incorporated

The following firms have principals who are members of this Association engaged as professional engineers in engineering work independent of salaried employment or sales promotion.

The revenue derived from the sale of advertising space assists the Institute in publishing THE ENGINEERING JOURNAL on a regular monthly basis. Listed above are the names of the Companies and individuals whose advertisements appear in this issue.

ADVERTISING OFFICES

QUEBEC: J. E. Donovan, Manager Advertising, Sales Representative—Charles R. Amey, 2050 Mansfield Street, Montreal, Phone: VIctor 2-8121
ONTARIO: L. G. Barnum, Manager, Advertising Sales, 160 Eglinton Ave. E., Suite 103, Toronto, Phone: 485-0789
WESTERN CANADA: W. George Turner, 501 - 191 Lombard Ave., Winnipeg, Man., WH 3-9123
UNITED KINGDOM: H. A. Mackenzie, 4A Bloomsbury Square, London, W.C.1, England. Phone: HOlborn 3779
NEW ENGLAND STATES: R. G. Melendy, 17 Maugus Avenue, Wellesley Hills 81, Mass. Phone: CEdar 5-6503
CHICAGO: W. Reynold Ratz, 549 W. Randolph St., Chicago 4, Ill. Phone: ST-2-8811
NEW YORK: John H. Boyd, 17 East 45th Street, New York, Phone: MUrray Hill 7-0654
CALIFORNIA: Dunkle/Lehman Company, 740 South Western Ave., Los Angeles, Calif. Phone: DUnkirk 7-6149

EIC

THE
ENGINEERING JOURNAL

VOLUME 45 NUMBER 6 JUNE 1962

BLISHED MONTHLY BY THE ENGINEERING INSTITUTE OF CANADA, 2050 MANSFIELD ST., MONTREAL 2, QUE., CANADA • TEL. VI. 2-8121

Printed in Toronto

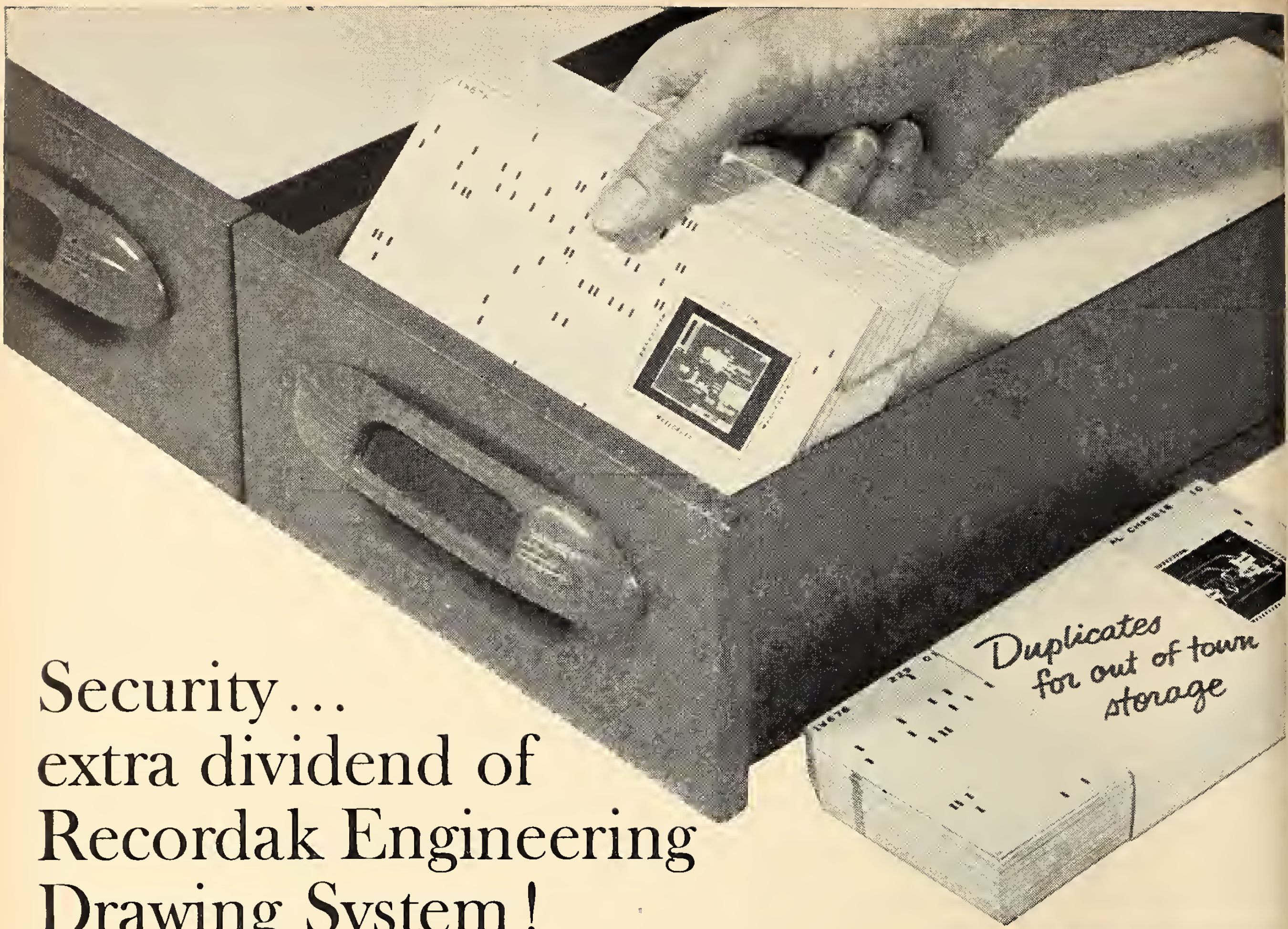
Price $6.00 a year in Canada, British Possessions, United States and Mexico. $7.50 a year in Foreign Countries. Current issues, 75 cents a copy, back issues from $1.00 per copy up. To members, affiliates and other bona fide engineers in Canada—no charge. Authorized as second class mail, by the Post Office Department, Ottawa, and for payment of postage in cash.

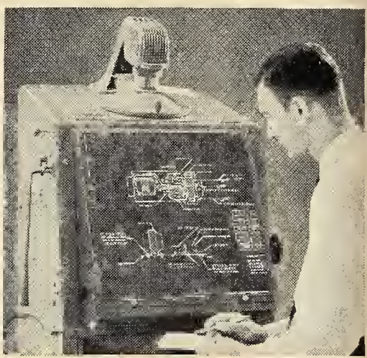
MEMBERSHIP

CCAB BNA

Indexed in
The Engineering Index
The Applied Science and Technology Index

CONTENTS


Duplicates for out of town storage



IN THIS ISSUE

Many of the major rivers and streams in northern Alberta, the Peace River block in British Columbia and the southern portion of the Yukon have cut through shale deposits which have been highly consolidated by the weight of glaciers many hundreds of feet thick. Engineering construction in these valleys frequently produces changes in the stability conditions sufficient to precipitate major earth movements. Experience in the area to date has shown that it is very difficult to determine by conventional subsoil exploration methods where such instabilities will develop. Moreover, conventional methods of stability analysis are inadequate to accurately assess the stability of these slopes as they exist naturally or as they may be modified by engineering works.

Recently, very complete investigations have been undertaken at two locations where major instability has developed incidental to road and bridge construction. In their paper entitled, ***"Landslides in Over-Consolidated Clays"***, **R. M. Hardy**, M.E.I.C. **E. W. Brooker**, M.E.I.C. and **W. E. Curtis**, A.M.E.I.C. have described the conditions encountered, and the investigations made for these two sites. The paper shows the inadequacies of conventional methods of stability analysis when applied to these conditions, and presents a modification to the conventional effective stress stability analysis which appears to permit a reasonably accurate assessment of the stability conditions to be made. The significance of the modified stability analysis in the design of corrective measures to improve the stability conditions is also discussed.

The new Fifth Edition of CSA Standard S16, "Steel Structures for Buildings", contains several modifications and revisions when compared with the requirements of the Fourth Edition published in 1954. Technological progress in steel-making and fabrication methods, as well as extensive research into the actual behaviour of steel members and connections, made the publication of an up-to-date specification imperative.

In their paper, ***"Commentary on CSA Standard S16-1961"***, **W. G. Mitchell**, M.E.I.C., Chief Design Engineer Canadian Bridge Works, at Dominion Steel and Coal Corp. Ltd., Riverside, Ont., and **D. L. Tarlton**, Development Engineer at the Canadian Institute of Steel Construction, Inc., Toronto, hope to serve the structural designer by offering a logical analysis of the reasons for the major revisions in the Fifth Edition of the CSA Standard S16, and in so doing, minimize the possibility of an incorrect interpretation of the specification requirements.

Engineering education is at present in a state of flux. It is the subject of widespread discussion and recent years have brought forth a profusion of conflicting views. Some of these views are progressive, and range from the mild to the extreme; others are conservative or reactionary, University engineers are now in the throes of making what are probably the most important decisions in the history of engineering education.

In his paper, ***"Urgent Tasks in Engineering Education"***, **D. M. Myers**, M.E.I.C., Dean, Faculty of Applied Science, University of British Columbia, stresses that rigid and sometimes dogmatic adherence to what have hitherto been regarded as basic principles, might very well lead to stagnation and even extinction of engineering as a profession. The paper deals particularly with the requirements for uniformity and breadth in engineering education. The author examines these two factors and makes suggestions as to how to achieve adequacy without undue uniformity, and depth without undue sacrifice of breadth.

This 75th Anniversary issue of the Journal is different from the regular issues both in format and content. The format is more open and varied.
Special content includes an illustrated story of major Canadian engineering achievements since 1887. We acknowledge the impossibility of including every notable development or project during the past 75 years. In our general review of engineering we have selected a few dozen stories which we hope depict both the technical and the geographical scope of the developments. In many instances we have illustrated these achievements with photographs obtained through the courtesy of the Dominion Archives.

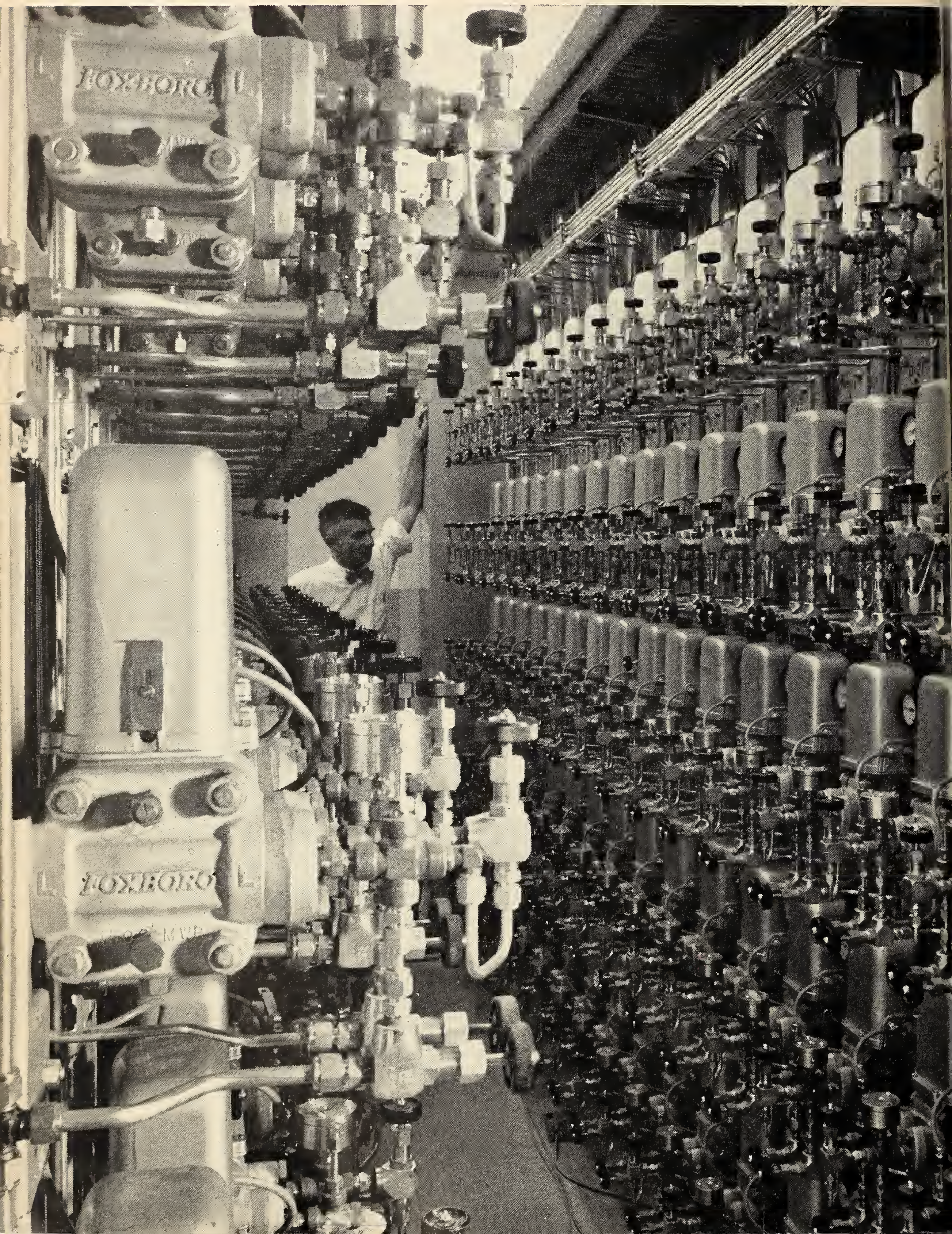
The story of the St. Lawrence Seaway is familiar to all of us. For several years during its construction monthly reports were carried in the Engineering Journal. And we published several special Seaway issues and many Seaway papers. The text of the Seaway story in this issue then, is brief and designed only to jog memories. Included is some history, and many of the statistics.

The history of the Engineering Institute of Canada is the story of engineering in this country. It is filled with excitement and hard work, and some amazing personalities. This complete history is being prepared. Obviously, though, its scope is far beyond the space limitations of this Journal. We have prepared a brief chronology which we trust will serve until the history has been completed.

The Trans-Canada Microwave Link has not received the public attention that other projects, such as the Seaway, have attracted. It is an amazing engineering project and we are pleased to tell this story in our Anniversary issue of the Journal.

Canada's hidden mineral wealth allowed this country to change from a pastoral to an industrial nation. The exploitation of this wealth required the skills of engineers of all disciplines.

high sustained accuracy o
cited at Chalk Rive



Canadian Engineering 1887 . . . . . .

Surveying at the site of the Lachine Bridge near Montreal, 1887. (Public Archives of Canada)

The challenge of great distances and stubbor terrain provided the spur to Canada's engineers afte the emphasis shifted from military to civil engineerin The most prominent engineers of 75 years ago mad their reputations as builders of roads, canals or rai roads. And two of the strong forces behind the found ing of what now is the Engineering Institute of Can ada were the builders of civil engineering project and the teachers of engineering.

This flashback of outstanding engineering achieve ments since 1887 will start with the building of th Canadian Pacific Railway even though its completio predated the founding of the present E.I.C. by on year.

It would be foolish to assume that in a few page and a few dozen paragraphs that a comprehensiv story of Canadian engineering could be presented. I is hoped only that it will touch a few highlights of the work of Canada's amazing engineers.

One of the most difficult stretches of the entire Canadian Pacific Railway was built through Kicking Horse Pass in the Rockies. (Public Archives of Canada)

THE CPR

Even in this day of heavy-duty equipment, well-honed surveying skills and efficient materials handling the job of building a railroad across a country like Canada would be considered extremely trying.

Consider the task that faced the builders and planners in the years immediately following Confederation. Required were two ribbons of steel to bind together a nation which wasn't really convinced it wanted to be Canadian. There were two obvious problems.

The first was to link Eastern Canada with the Prairies over the top of the Great Lakes. This was a 1000-mile stretch through uninhabited, severely rocky country pocked by thousands of lakes.

This familiar picture shows Donald Smith driving the golden spike on the C.P.R. line at Craigellachie, B.C., November 7, 1885, 9:30 a.m. (Public Archives of Canada)

The second was to link the Prairies with British Columbia which was becoming impatient with the delay in the promised trans-Canada railway.

Sandford Fleming, chief engineer in charge of surveying, recommended that the Rockies be crossed at Yellowhead, but the builders had to recognize conditions other than engineering and it was decided to drive the railroad through at Kicking Horse Pass. Construction of a line over the heavy grades of Kicking Horse Pass was one of the great achievements in railroad engineering.

The link between the Prairies and British Columbia was formally completed at Craigellachie, B.C., on November 7, 1885 with the driving of the last spike by Donald A. Smith, principal organizer of the company.

Five days earlier the section between Callander and Port Arthur was rushed to completion to help the movement of troops rushing west to crush the Riel Rebellion.

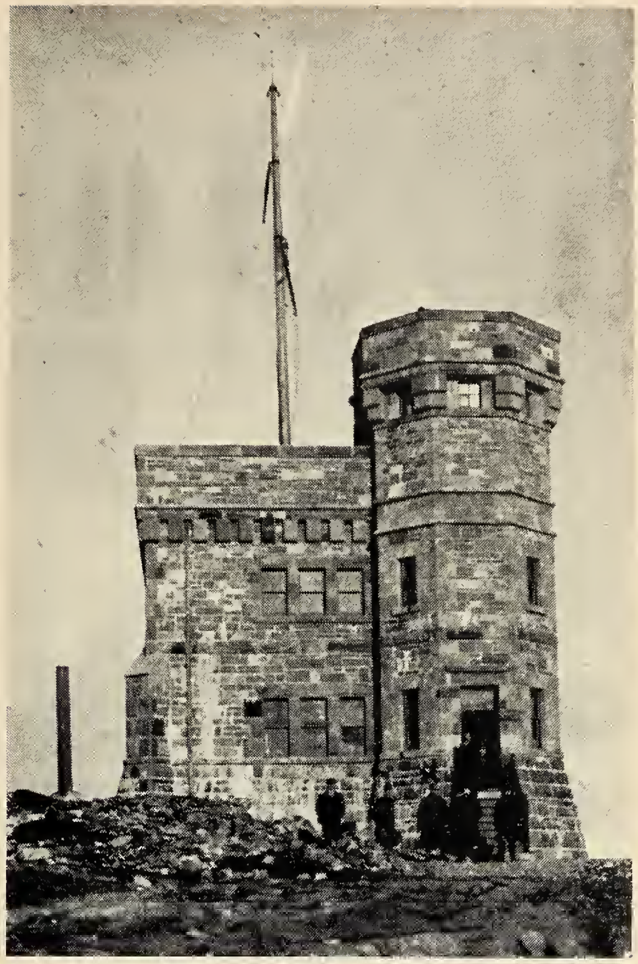
The first train left Montreal for Vancouver on June 28, 1886.

THE RUSH FOR GOLD

Although the Yukon Gold Rush had only an indirect bearing on Canada's engineering community at the beginning, there was ultimately a great need for engineers to help develop the Territory. In view of this, a few sentences on the rush are appropriate.

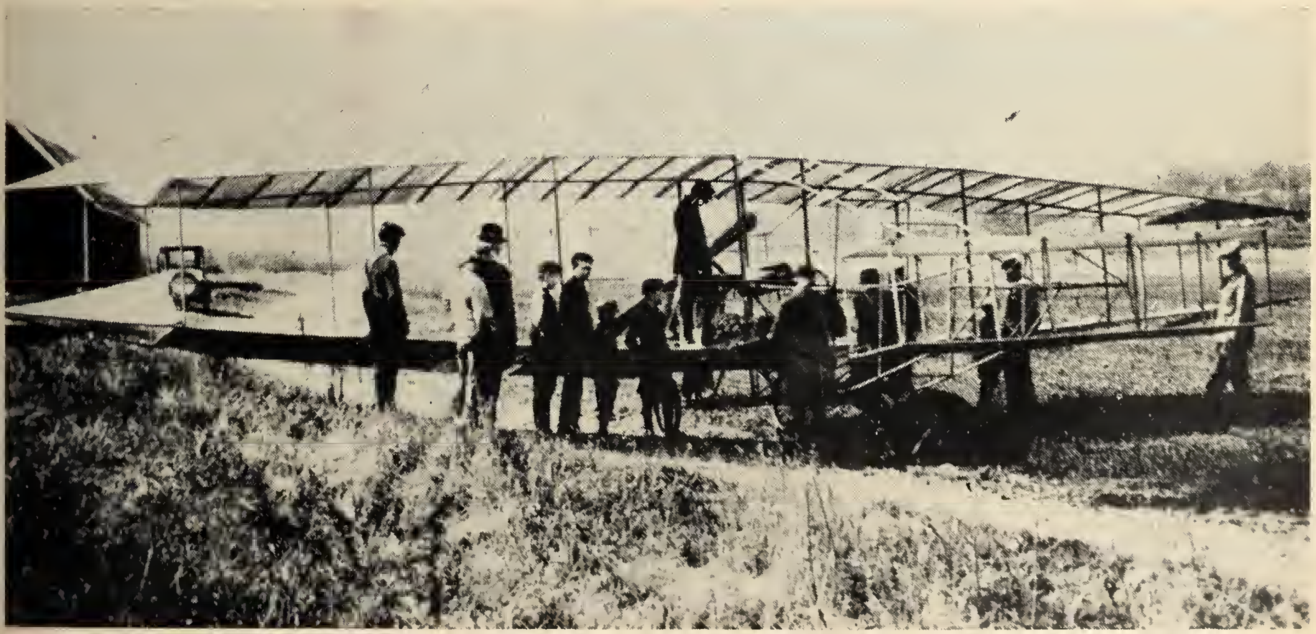
The surface of the Yukon was being scratched as early as the 1840's, and by the early 1870's prospectors by the hundred had invaded the Territory.

The madness began in 1896 when George W. Carmack struck gold on Bonanza Creek, a tributary of the Klondike. By 1898 Dawson had a population of 25,000 as the lure of wealth for the finding attracted hopeful or desperate men from all parts of the world. During a very few years the more accessible placer gold was removed, and quiet returned to the Yukon.



Outside Cabot Tower on Signal Hill in Newfoundland where Marconi received the first trans-Atlantic radio signal, 1901. (Public Archives of Canada)

The efforts of two young engineers were repaid when the Silver Dart flew over the ice of the Bras d'Or Lakes near Baddeck, N.S., to inaugurate powered flight in Canada in 1909. (Public Archives of Canada)



Above Bonanca, the Yukon, 1899. (Public Archives of Canada)

LACHINE CANAL

The St. Lawrence River-Great Lakes Waterway is dealt with in greater detail in other sections of this Journal, so these few remarks are confined to the early Lachine canals.

The Lachine rapids just above Montreal were the first major frustration of those who wanted commerce between Montreal and the inland. About 1700 a mile-long canal wide enough for one canoe was planned, but never built. In 1779 the Royal Engineers built a canal which incorporated locks. This canal was enlarged several times until it was able to accommodate six barges side-by-side.

The first Lachine canal as such was finished in 1885. There were seven locks, each 100 feet long, 20 feet wide, and with a water depth of five feet at the sills.

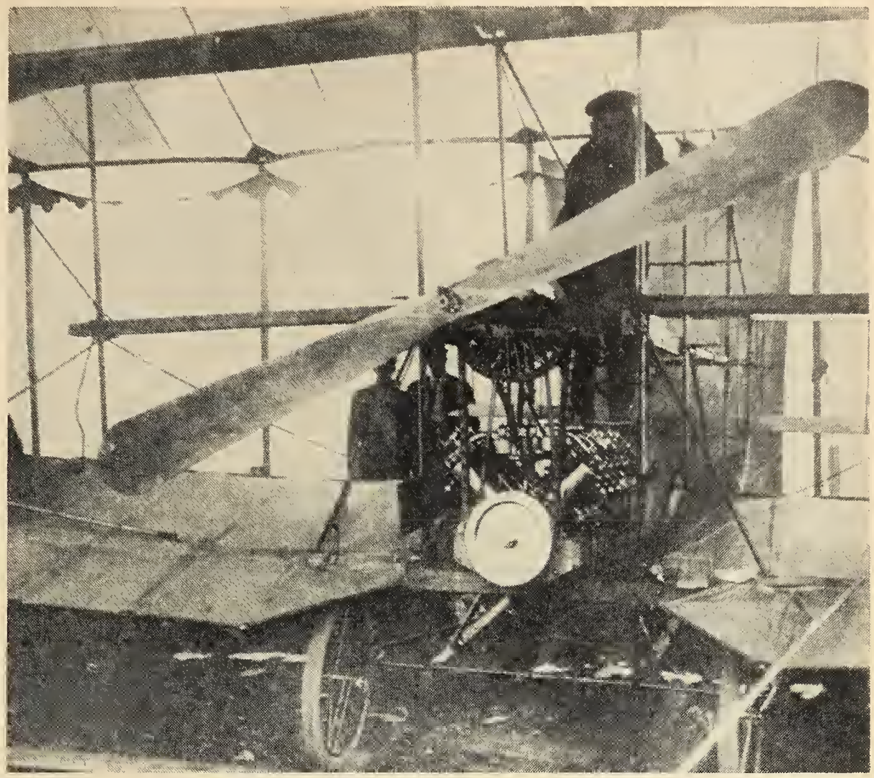
POWERED FLIGHT

Powered flight in Canada began with the work of two young engineers. When the Silver Dart flew by its own power over the ice on the Bras d'Or Lakes at Baddeck, N.S., the controls were in the hands of John Alexander Douglas McCurdy, a graduate in engineering from University of Toronto. Watching anxiously was the other half of the Silver Dart's construction team. Also an engineer and a graduate of University of Toronto, his name was Frederick Walker (Casey) Baldwin. The previous year Baldwin had become the first British subject to fly an aeroplane.

Both men gave decades of service to Canada long after the inaugural flight of the Silver Dart. Baldwin's reputation was enhanced by his specialized knowledge of hydrofoils. McCurdy stayed many years in aviation and from 1939 until 1947 served as assistant director general of aircraft production in the Department of Munitions and Supply. He later served for five years as Lieutenant-Governor of Nova Scotia.

Called variously the Lachine Bridge, the St. Lawrence Bridge and the Mercier Bridge, this structure was completed in 1887. (Public Archives of Canada)

This seemingly frail craft, the Silver Dart, carried Canada into the age of powered flight in 1909. (Public Archives of Canada)



GOUIN RESERVOIR

Northern Quebec is well endowed with large lakes. It would seem foolish to try to compare a man-made lake with the large expansions of natural water. But the Gouin Reservoir, more than 400 miles north of Montreal, with an area of about 500 square miles, compares very favorably.

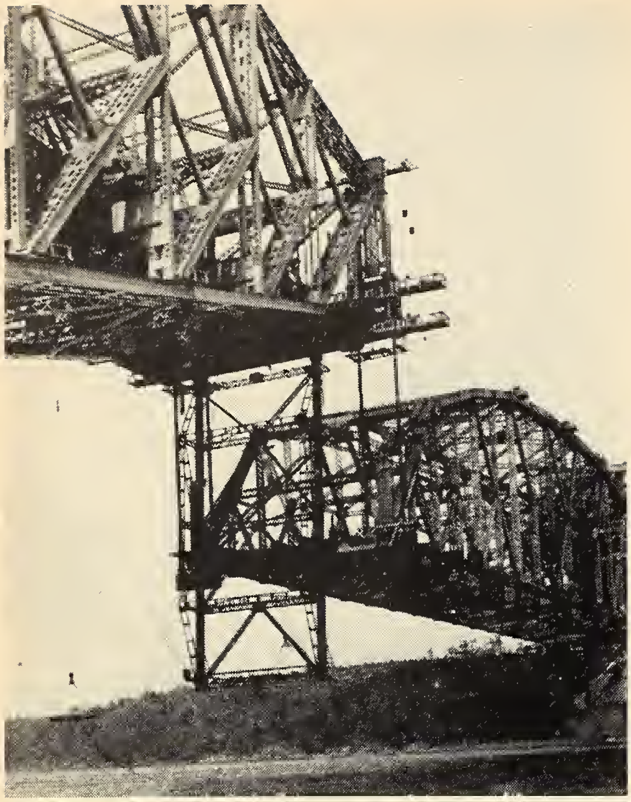
The Reservoir is in the upper reaches of the St. Maurice River and was formed in 1918 by the construction of a dam built by the Quebec Streams Commission. The Reservoir has an average depth of about 17 feet and has a capacity of some 160 billion cubic feet. The Reservoir and dam are largely responsible for the flow of water down the St. Maurice to the St. Lawrence, thus permitting large power developments. Both the dam and the Reservoir are named after Sir Lomer Gouin, the Premier of Quebec who established the Quebec Streams Commission.

THE QUEBEC BRIDGE

Even today the Quebec Bridge is a structure worthy of respect, and some awe. Sixty-two years ago, when construction began, it was a project fit for marvel. The bridge is located six miles up the St. Lawrence from Quebec City and was designed as the largest cantilever bridge in the world.

Before the bridge was completed in 1917, though, two disasters had taken 88 lives. The project appeared to be nearing completion in the summer of 1907 when one of the cantilever spans collapsed at a cost of 75 lives. A Royal Commission subsequently attributed this disaster to errors in engineering judgement. The second tragedy occurred in 1916 when the centre span was being raised into position. This disaster, which took 13 lives, was attributed to a defective steel casting.

The first combines arrived in Western Canada in 1922. Today there are 100,000. (Public Archives of Canada)



The centre section of the Quebec Bridge is being raised to meet the cantilever spans. 1917 (Public Archives of Canada)

At the turn of the century it was largely manpower that transformed the plans of the engineer into reality. (Public Archives of Canada)

AGRICULTURAL MACHINERY

Until relatively recently Canada was known primarily as a producer of food and raw materials. And as this was largely accurate, the application of engineering skills to helping make the farmers' job more efficient was a fundamental contribution to the life of Canada.

Two early and still prominent names in the agricultural implement field in Canada were Daniel Massey and Alanson Harris. Both men established ships in southern Ontario, Massey in 1847 and Harris 10 years later. Massey specialized in ploughs, harrows, scufflers and rollers, while Harris started by making revolving hay rakes. Both firms added to their lines and marketing areas with Harris quite aggressive in western Canada even before the completion of the Canadian Pacific Railway.

Other important Canadian manufacturers existed and by late in the 19th century winds of merger began blowing. A large area of bitter competition ended in 1891 when Massey, Harris, J. O. Wisner of Brantford, Ont., and the Sawyers of Hamilton merged to become the Massey-Harris Company.

Early in this century the field was entered by International Harvester, which established a subsidiary, and by the Canadian firm, Cockshutt Plow Company. These two and Massey-Harris account for more than 70 per cent of Canada's farm implement business.

The opening of the West provided the first major impetus, and technology has taken it from there. The tractor replaced the horse, and through modifications became more than just a mechanized puller. Combines were introduced to Canada only about 40 years ago and now there are somewhere in the area of 100,000 of them in this country.

In 1954 the Ferguson Company Amalgamated with Massey-Harris as Massey-Harris-Ferguson to become the world's third largest producer of agricultural implements.

PETROLEUM

Oil was being produced in small quantities in Southwestern Ontario for several years before the big strike at Titusville, in Pennsylvania. The Titusville strike stirred interest, through, and in 1862 a well at Petrolia, near Sarnia, is said to have yielded 3000 barrels a day. The rush began, and as strike after strike was made great quantities of oil were wasted, being allowed to flood the land and the streams. Towards the end of the century these wells began to yield their oil more reluctantly and today the bigger producers in the Petrolia area yield only a few barrels a day.

When one thinks of oil now he almost inevitably thinks of Alberta which accounts for more than 90 per cent of Canada's production. The Turner Valley field has produced natural gas since 1914 and oil since 1922. The exploration boom followed the Second World War, with the most notable discoveries being Leduc in 1947 and Redwater the following year.

The Canadian Arctic is thought to contain rich reserves and the Norman Wells field has been producing for 42 years. Only though no reserves as commercially attractive as those in Alberta have been found, oil is known to exist in Cape Breton and in some parts of Quebec's Gaspe Peninsula.

One formidable obstacle to the Klondike gold was the Chilkoot Pass. Many thousands failed, but 22,000 conquered the Pass.

NEWSPRINT AT CORNER BROOK

Some projects stand the test of time well. One of these is the paper mill opened in Corner Brook, Nfld., in 1923. The colossal plant of the Humber Development Company cost several million dollars. Today it remains one of the largest paper mills in the world. It now is operated by Bowater's Newfoundland Pulp and Paper Mills, Ltd.

WELLAND CANAL

As with the Lachine Canal, the Welland is mentioned elsewhere in this issue. This account touches only upon the earlier years of the Canal.

For many years the Niagara Falls appeared an almost insurmountable barrier between Lake Ontario and the remainder of the Great Lakes. Until 1829 when a private company completed a small canal, all

The Quebec Bridge remains a monument of engineering in spite of two tragedies. Here the centre span is being raised in place in 1917. (Public Archives of Canada)

While Marconi (extreme left) looks on, his men struggle with his ingenious kite at Signal Hill, Newfoundland, 1901. (Public Archives of Canada)

cargo had to be transhipped by land around the falls and rapids. Twelve years later the government purchased the private canal and deepened it to nine feet. After Confederation the Welland was made to conform with new canal standards. Its length was 270 feet, its width was 45 feet and it was 14 feet deep.

The present canal, which was rebuilt again between 1913 and 1932, has a depth of 27 feet. Locks 1 to 7 are lift locks, while lock 8 is a guard lock. The guard lock is 1380 feet in length, the longest in the world. The Welland Ship Canal overcomes a difference in level of 326 feet between Lake Ontario and Lake Erie.

ATOMIC ENERGY

Of all the topics covered in this brief review, probably none suffers more than atomic energy by being treated in just a few paragraphs.

While most of the fundamental research and discoveries of 60 and 70 years ago were made in Europe, Canadian scientists contributed fundamental discoveries almost from the beginning. Most of the work in Canada was done by a handful of men in various universities, and by a small group of scientists at the National Research Council.

The advent of the Second World War coincided with the discovery that atomic fission might result in the release of fantastic amounts of energy. The war gave impetus to research and in 1943 a joint Canadian-British atomic energy project was established in Montreal under the direction of the National Research Council.

The work of this group soon was co-ordinated more closely with that of American scientists and a decision was made to establish a small heavy water reactor for plutonium production at Chalk River, north of Ottawa.

Eventually the importance of this work was recognized by the creation of its own administrative arrangement, a crown corporation called Atomic Energy of Canada Limited.

This corporation has been involved in the design and construction of increasingly powerful reactors, and is striving toward economical nuclear electrical energy. The Hydro Electrical Power Commission of Ontario is co-operating in this venture and plans to add power from AECL's Douglas Point plant to its own power grid.

OTHER

This small list of topics chosen for treatment in a few paragraphs was designed only to show a broad spectrum of engineering from 1887 to the present. Other projects are dealt with by picture only, or by photograph and cutlines.

TRANS-CANADA MICROWAVE LINK

In February, 1955, at Quebec City, final technical preparations were made for a start on one of the greatest all-Canadian projects of the 20th Century—construction of the Trans-Canada Microwave Radio Relay System.

Believing that the Bell company had found the basic answer to its long distance expansion problems in Ontario and Quebec, the Trans-Canada Telephone System felt confident that microwave could also provide the scores of essential long haul telephone circuits needed to handle the ever-increasing volume of calls between eastern and western Canada.

Even earlier, the Trans-Canada Enginering Committee had examined technical aspects of the Canadian Broadcasting Corporation's request for a quotation in connection with use of the proposed microwave chain for television purposes; top executives from each of the seven telephone companies in the Trans-Canada Telephone System had met under the chairmanship of T. W. Eadie, President of The Bell Telephone Company of Canada, to determine costs, operational expenses and rates. This "Quebec Conference" of engineers, however, marked the step which would lead directly to actual work on the project on a national scale.

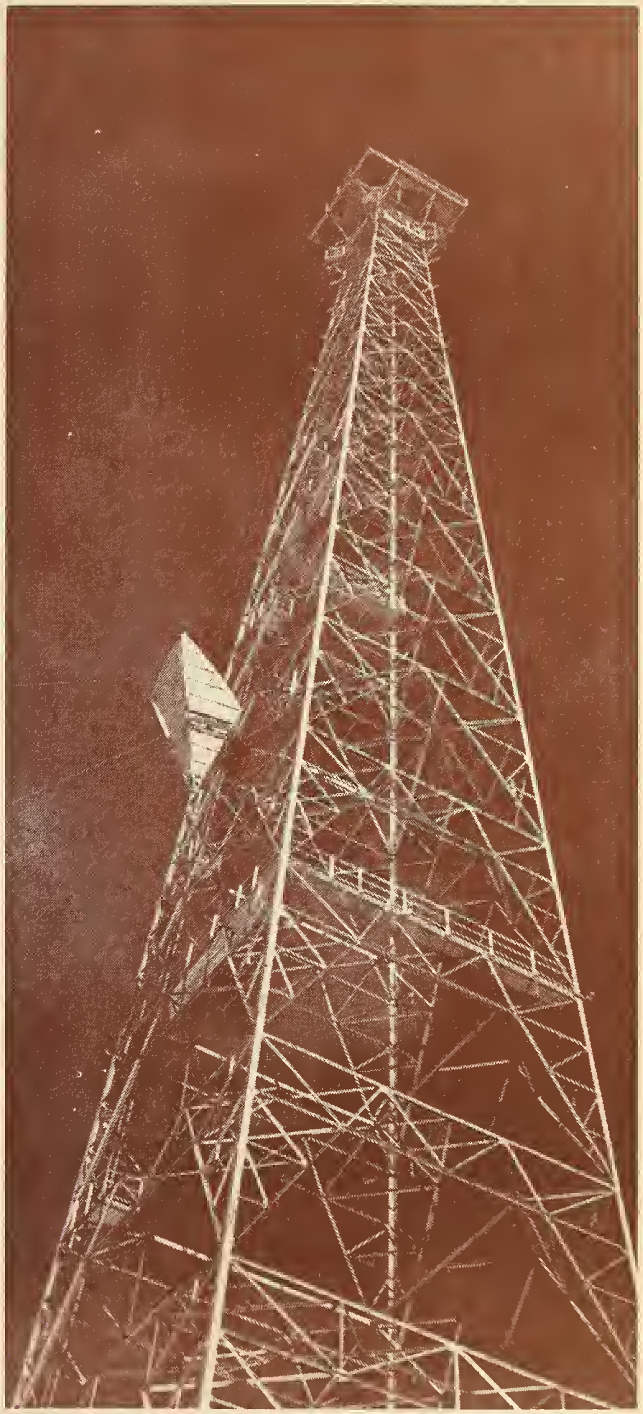
In a short time, every phase of the engineering design of the microwave chain had been checked and studied. All was in readiness for wholesale path-testing in various sections of the western, eastern and maritime provinces.

Speed was of the essence if progress on the chain was to keep pace with construction of new television stations that were springing up in every province.

In one month engineers had completed the design of the network. Taking into consideration the number of unknown factors involved, this in itself was a remarkable achievement. The only major microwave system in Canada at that time had been built by the Bell Telephone Company in Ontario and Quebec.

The Bell company had seen the need for a large-scale extension of its long distance telephone facilities when the tide of social and economical expansion made itself felt in Canada after the Second World War. Following extensive engineering studies, it became apparent that microwave radio relay would best meet the requirements with regard to economy, reliability and potential growth. The system envisaged also would allow for the transmitting of network television programs, thus filling another communications need.

Use first was made of microwave radio relay in Canada in 1953 for the vital Montreal-Ottawa-Toronto triangle. The chain also extended from Toronto to Buffalo for television purposes. In the summer of 1954, a 180-mile stretch between Montreal and Quebec City was placed in service.



The basic Trans-Canada Telephone microwave network is made up of some 150 relay stations stretching from Sydney, N.S. to Victoria, B.C. Tallest tower is this 350-foot giant at Olive, Ont., about 30 miles west of North Bay.

A 22-mile access road was required to reach this 50-foot microwave tower of the Trans-Canada Telephone System at Salmo, B.C. Set 6,990 feet above sea level—making it the highest of the coast-to-coast network—this tower is one of the units which manufactures its own electric power. Three diesel generators supply the power for the station which is located too far from commercial power sources to permit economical construction of a power line.

Bell Telephone made known its ideas on a cross-country microwave system to six other Trans-Canada Telephone organizations—both government and share-holder-owned companies—consisting of the Maritime Telegraph & Telephone Company, the New Brunswick Telephone Company, the Manitoba Telephone System, Saskatchewan Government Telephones, Alberta Government Telephones and the British Columbia Telephone Company.

Agreement was reached therefore to proceed with the plan, with each company in the System assuming full responsibility for the construction and maintenance of the chain in its own particular territory. The entire coast-to-coast network was estimated to cost some $50 million.

That is what led to the work of actually designing the Trans-Canada microwave chain. Right across the country, engineers using the best maps to be had, (for certain sections maps were not available and extensive aerial surveys were undertaken that they might be prepared,) studied topography and tentatively selected routes. Because curvature of the earth had to be taken into account in finding line-of-sight paths for the microwave beams, they searched for elevated sites to obtain the proper distance between stations.

Next, special crews set out to perform on-the-spot inspections. They made special note of the accessibility of each site; higher land, trees or buildings that could interfere with transmission; the likely cost of access roads; and the availability of commercial power.

Then followed the transmission tests, involving use of transmission measuring apparatus, intercommunication radios, portable aluminum towers which could be erected to a height of 200 ft. within 24 hours, and parabolic test antennae with associated winches. These tests often presented difficulties. In several instances, dense bushlands had to be cleared before testing equipment could be conveyed to the prospective site.

But engineers came through with their most ingenious ideas when faced with seemingly insurmountable problems. In British Columbia, for example, they hit upon a simple but extremely effective method of avoiding the costly business of transporting heavy equipment up to tentative mountain sites. At each proposed site, an engineer established his exact location with walkie-talkie; then, using an ordinary hand-mirror, he reflected the sun across to his neighbour. In this way, the clearance between the light path and the top of any possible obstruction could be measured geometrically.

Transmission tests largely determined whether or not the tentative sites were accepted. Upon selection of a site, the option was taken up and the property purchased.

Once the site had been secured, access roads were built, and this was not always an easy task. At Creston, B.C., the access road has a 20% grade and 33 switchbacks in two miles. Between Hearst and Long Lac in Northwestern Ontario where a wide area had to be bulldozed through the bush, the contractor was obliged to organize a caravan for his men, with mobile bunk-house, restaurant and water-wagon, drawn on trailers along the Trans-Canada Highway, parallel with the planned microwave route. And at the Dog Mountain site near Hope, B.C., steep slopes and rock outcrops made an access road of any description quite out of the question. Instead, an aerial tramway, 11,800 ft. long was constructed. The tramway lifts men and material through 4,400 ft. at speeds of between five and 10 miles an hour.

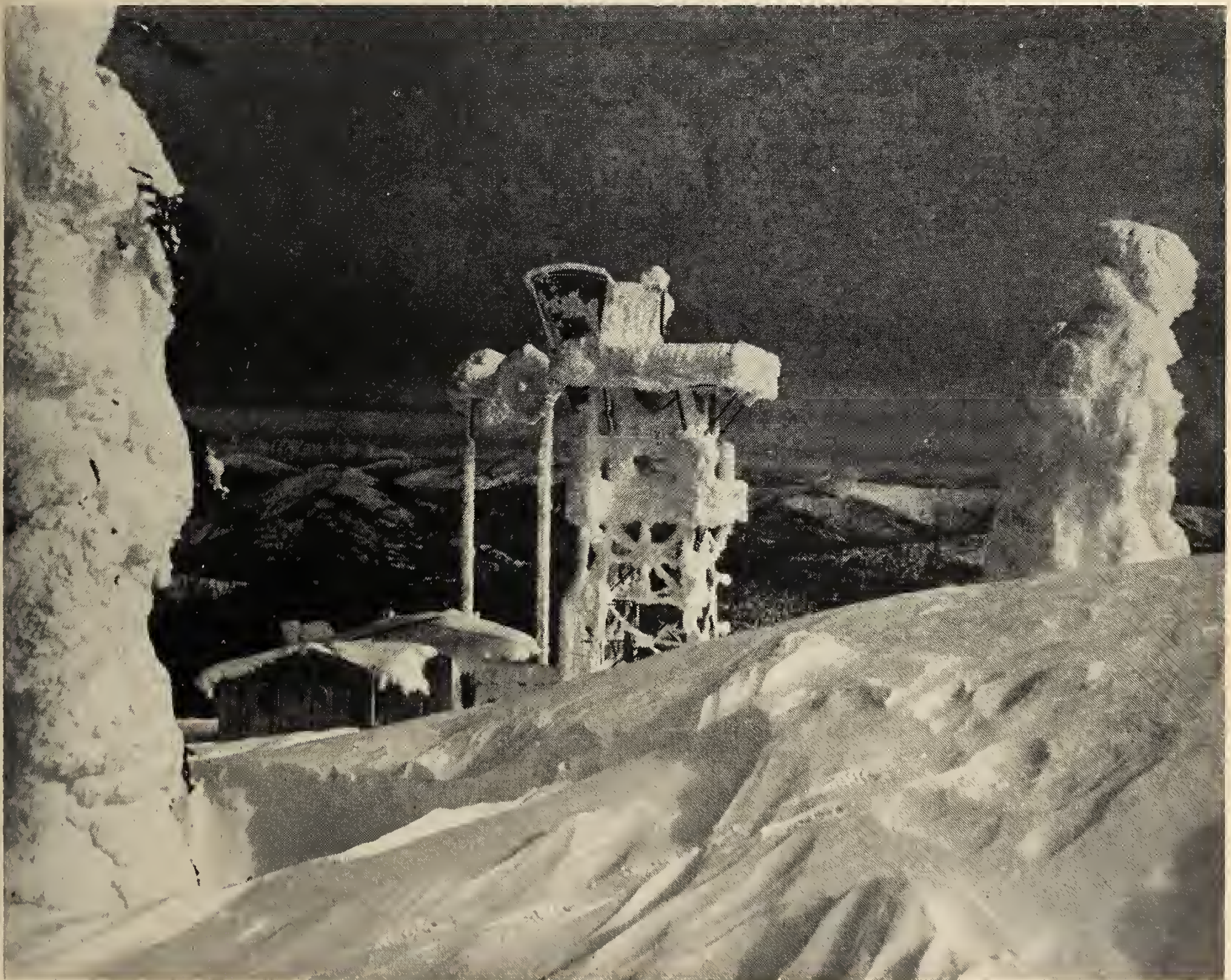
After construction of access roads came foundation work, and the erection of small buildings to house radio equipment and associated apparatus, followed by the huge steel towers, anywhere from 40 to 670 ft. high and weighing as much as 120 tons. Each of these three steps toward placing a relay station in service often presented its own peculiar complications.

The foundation for one side of an equipment building at Hedley, B.C., where a shortage of working space was encountered, had to be 13½ ft. high. In Southern Saskatchewan, tower foundation work ran into trouble due to gumbo soil conditions. Here, the gumbo soil was extremely deep and it tended to be quite liquid for several feet below the surface. The answer was regular spread footings placed well below the frost line, with each footing bound to four reinforced concrete piles, 15 ft. long, constructed in holes made in the gumbo.

All of these complexities, and many more, were ironed out and, despite an exceedingly tight schedule, the various sections of the microwave chain traced their way across the countryside, and went into service as originally planned.

The Toronto-North Bay-Winnipeg section was placed in operation in September, 1956. By December of that year, the Saint John-Moncton-Halifax-Sydney stretch had opened, and Vancouver and Victoria interconnected. April, 1957, saw the Winnipeg-Regina section of the chain in operation, followed by Regina-Saskatoon in June, Regina-Calgary and Edmonton-Calgary-Lethbridge sections in November, 1957. Charlottetown was also added to the network in November, 1957. The Quebec City-Saint John link was opened in February, 1958, bringing an estimated half-a-million viewers in the three maritime provinces within the scope of the national television network. By this time, the microwave chain was complete as far west as Calgary. The final link was the 572-mile, 19-tower stretch between Calgary and Vancouver opened on July 1, 1958, which marked completion of the entire coast-to-coast project.

This microwave radio relay station at Creston, B.C., is at an altitude of 6,900 feet. Its access road has a 20 per cent grade and 33 switchbacks in two miles.



The Trans-Canada Telephone System's microwave radio relay system covers some 3,900 miles from Sydney, Nova Scotia, to Victoria, and is recognized as the longest in the world. Spur lines already in service to other Canadian centres total an additional 1,400 miles.

Additional microwave facilities are beginning to reach the expanses of Northern Canada. On June 1, 1958, The Bell Telephone Company of Canada and Quebec-Telephone opened a tropospheric scatter system that provides scores of telephone circuits to help open up untold resources of Northern Quebec and Labrador centered in the Schefferville (Knob Lake) and Goose Bay areas.

In itself tropospheric scatter transmission – which permits relay stations to be placed as much as 200 miles apart instead of the 30-mile average in the ordinary microwave system – represents a device of great potential opening up remote areas.

Inauguration of the Montreal-North Bay microwave radio relay network took place in the spring of 1959. Besides telephone conversations, the Bell Telephone system carried French network television programmes for the Canadian Broadcasting Corporation from Montreal to Rouyn via Ottawa, North Bay and Sturgeon Falls. It also provides an alternate route for English network TV programs.

A new Bell Company microwave radio relay system between Toronto-London-Windsor was also opened in the spring of 1959 to provide hundreds of long distance telephone channels between these cities. Initial installations provided 120 circuits between Toronto and London; 60 between London and Windsor. When fully developed, the system will carry as many as 480 telephone conversations simultaneously on each of five radio channels—2,400 conversations in all. The Western Ontario system, which is linked with the Trans-Canada system, has eight relay stations and two terminal points. The latter are located at Toronto and Windsor.

During 1959, a link was built by the Canadian National Telegraphs to connect some three additional service points in Newfoundland to the coast-to-coast television network at North Sydney, N.S.

Since September, 1959, the Trans-Canada Telephone System microwave network has been extended to include: Matane and Rouyn, in Quebec; Prince Albert, Swift Current, Moose Jaw and Yorkton, in Saskatchewan; Medicine Hat and Lethbridge in Alberta, and from Edmonton, east to Lloydminster on the Alberta-Saskatchewan border; Trail, Kelowna and Kamloops, in British Columbia.

A time delay system is in effect between Calgary and various points in Alberta, Saskatchewan and British Columbia. This delay system permits viewers to see their favorite programs at the same local time in each of the cities where they are broadcast.

In June, 1960, a survey team left Trouble Mountain in Northern Quebec to map a route for a radio relay system that now brings direct telephone service to the North Shore community of Gagnon. A joint venture of the Bell Telephone Company and Quebec-Telephone, the system has been in operation for almost two years and is scheduled for conversion to dial in 1962.

In July, 1961, S. W. Caldwell, president of CTV Television Network Limited and The Bell Telephone Company of Canada, acting on behalf of the Trans-Canada Telephone System, reached agreement concerning the building of a new facility for this new independent television network.

Areas in which television viewers will have a choice of two Canadian network programs in English will centre in Halifax, Montreal, Ottawa, Toronto, Winnipeg, Calgary, Edmonton and Vancouver—where the eight charter CTV member stations are located—other areas will be added as the network expands.

Equipping the 3,400 mile electronic skyway to carry live television for the new network will involve additional installations in more than 130 of the telephone system's relay stations from coast-to-coast. In some cases, equipment buildings at the bases of microwave towers will be enlarged, and in others, additional antennae will be installed.

The present Trans-Canada microwave network will have an ultimate capacity of up to 12 two-way channels including two protection channels. Special gear will automatically substitute a protection channel for any regular channel which fades below a minimum level. A channel can carry up to 480 simultaneous telephone conversations whereas a television program requires the full use of one channel.

Like light, microwaves travel in straight lines at the speed of 186,000 miles a second. Relay points, therefore, are needed every 25 to 30 miles to provide line-of-sight paths. Contained in the network are 139 relay points. The galvanized steel towers are staggered to ensure that signals from one tower do not overshoot the next tower in line and pass on to the third.

The Trans-Canada microwave chain operates broadly in this way: Words spoken into the telephone, and images picked up by the television camera, are converted into electrical impulses. These impulses are fed into the microwave system at terminal stations, such as those at Vancouver and Montreal. Carrier equipment then boosts their original frequency to that of the microwave system and they scoot up the inside of a hollow pipe wave-guide to a huge metal antenna, weighing 1,700 lb. and measuring about 20 ft. in height by 11 ft. wide.

The antenna focuses the microwaves into a beam only two degrees wide, aimed directly at the next tower in the chain. So efficient is the antenna that less than one watt of power—about the amount needed to operate a flashlight bulb—is needed to span the distance between the two stations.

Gathered in by the wide-mouthed antenna at the next station, the signals shoot down another length of wave-guide to the microwave relay equipment in the equipment building. Here, the signals receive a boost in power and then are sent up through another antenna and beamed at the next tower. This procedure is followed all along the route.

At the reception end of the network, further equipment reduces the telephone conversations and the television programs back to their original frequencies. After further degrees of processing, they then are fed to their outlets—the telephone receiver, or the television broadcasting station. The time taken from coast-to-coast is one-fiftieth of a second.

Relay stations are unattended, but the equipment is designed to diagnose any trouble that may occur and automatically sound the alarm. Each station is visited on a regularly scheduled basis for routine maintenance.

In addition to microwave network routes between Canadian centres, there are also links from Canada to points in the United States. These include Saint John, N.B., to Portland, Me., Montreal to New York, Toronto to Buffalo, Windsor to Detroit, Winnipeg to Fargo, N.D., Calgary to Helena, Mont., and Vancouver to Seattle.

ableway Derricks Johnson's Company,
hetford Mine, Quebec. Circa 1930.

ONE HUNDRED YEARS OF ASBESTOS IN CANADA

H. M. Woodrooffe

Supervisor, Industrial Minerals Sub-Division, Mineral Processing Division, Mines Branch, Department of Mines and Technical Surveys.

The original discovery in Canada of the mineral asbestos has been lost in the obscurity of history. It had been known in Eastern Canada many decades before its commercial importance was recognized. In a history of the Eastern Townships, published in 1869, there is reference to an occurrence in South Stukeley and the author observes "the finer varieties have been wrought into gloves and cloth which are noncombustible". That remarkable individual of the 18th Century, Benjamin Franklin, who was not unfamiliar with what is now Canada in 1725 approached Sir Hans Sloane, President of the Royal Society and Court Physician in England, with the following communication:

'June 2, 1725.

'Sir,

Having lately been in the Northern Parts of America, I have brought from thence a Purse made of the Stone Asbestus, a Piece of the Stone, and a Piece of Wood, the Pithy Part of which is of the same Nature, and call'd by the Inhabitants Salamander Cotton. As you are noted to be a Lover of Curiosities, I have inform'd you of these; and if you have any Inclination to purchase them, or see 'em, let me know your Pleasure by a Line directed for me at the Golden Fan in Little Britain, and I will wait upon you with them.

I am, Sir, your most humble servant,

Benjamin Franklin.

P.S. I expect to be out of Town in two or three Days, and therefore beg an immediate Answer.'

It is reasonable to assume that the source of his specimen was Quebec. The first reference to chrysotile occurring in serpentine in Canada by the Geological Survey is in a report covering the period 1847 to 1848. Little significance was given this observation. By 1860, a promising occurrence had come to light in the Seigniory of St. Joseph, Beauce County, close to the junction of the Rivière aux Plantes and the Chaudière River. Local residents of the period made reference to the mineral as "Coton à Pierre". Samples exhibited at an industrial exposition in London just 100 years ago excited more than academic interest in the mineral's potentialities. The amphibole varieties from Italy were at that time beginning to find an application in industry.

As a consequence of the construction of the Quebec Central Railway through the Eastern Townships in the late 70's significant deposits of chrysotile became known. The discovery in the Black Lake-Thetford region has been attributed, by some, to Robert Ward, and by others, to a Mr. Fecteau. The location of the original discovery is thought to be what became the Bennett-Martin pit, later acquired by the Asbestos Corporation Limited. Although Bell Company of London, England, had previously in 1875 begun developing an occurrence in Wolfestown Township, the first

Published, by permission of the Director, Mines Branch, Department of Mines and Technical Surveys, Ottawa, Canada.

production recorded commercially was in 1878 from the property of Andrew Johnson, at Thetford. Fifty tons of crude asbestos were shipped that year. Production has been continuous and today Andrew Johnson's pit is the underground mine of Johnson's Company Limited. Members of the Johnson family are still active in the company. The Bell Mine, operated by Bell Asbestos Mines Limited, and the pit operated by the King Brothers of Quebec, now the King Mine of Asbestos Corporation Limited, were developed about the same time.

Developments in the first few years were rapid. Favorable asbestos ground was quickly taken up, and by 1887 there were 11 operating companies which produced 4,600 tons of asbestos with an average value of $49.55 per ton. Canada's largest asbestos mine, the Jeffrey, operated by Canadian Johns-Manville Company Limited, had its beginning due to the initiative of W. H. Jeffrey. The mine which had been selling asbestos to the Johns-Manville Company was acquired by the Manville Asbestos Company in 1916. This became the Canadian Johns-Manville Company in 1918.

Canada's position as an exporter of asbestos was established in the beginning as the usefulness of the mineral was recognized in world markets. Because of its ability to be spun and woven into textiles the market grew rapidly. By 1890 the annual production exceeded $1 million.

In the early days all mines used hand labor. Manual drilling, breaking, and cobbing were the sequence of operations necessary for separating the longer fibres from the waste rock. As the market increased, the need for mechanical processing became apparent in order to market the quality of fibre desired by industry.

In the early days handling of the broken ore from the pit was in wooden boxes raised by simple horse-powered derricks. As the pits became larger and deeper, cableway derricks were installed. In some cases there were as many as 10 of these spanning 1000 ft., servicing a single opening. As the Jeffrey Mine developed, a steam railway was introduced to move the ore to the mill. As the mining operations were carried out at deeper levels there was a transition in the older pits to underground mines based on the block-caving principle.

The present-day asbestos open pit is a highly efficient undertaking, using advanced drilling techniques, breaking rock by ammonium nitrate-fuel oil explosives and loading by large power shovels. The broken ore is transported by modern trucks, some of which in one load are capable of transporting the tonnage mined during the entire first year of the industry's existence.

Mechanically separating fibre from the host rock was attempted experimentally in 1888 by a Cornishman, Matthew Penhale, Manager of the Scotish Canadian Company, operating mines in Coleraine and Broughton. His grandson is A. L. Penhale, President of Asbestos Corporation Limited. In early experiments screen separation alone did not prove successful. It was soon recognized, however, that aspiration from a deck would draw the opened fibres from the rock. This is the principle followed by the industry today in its large asbestos mills. The first mill for processing asbestos ore was erected at the Jeffrey mine in 1895. As mechanical separation took hold and was developed further, new equipment peculiar to the industry appeared.

Today milling of asbestos is a complex operation. Many different grades are required for industrial application and the preparation of these has developed much mechanical ingenuity. Recent mill installations are up to 14 stories high, incorporating the most up-to-date practices of dust control and materials handling. Large quantities of air are needed for the separation of the fibre and for dust control. The largest Canadian mill with an annual capacity exceeding 50% of the total output uses more than 2½ million cu. ft. of air per minute.

The asbestos industry has been aware of the need for quality control in preparing asbestos for today's markets. In 1961 the Quebec Asbestos Mining Association established a Fibre Standards Laboratory at the University of Sherbrooke to act as an impartial testing unit which will ensure uniformity of grading throughout the Quebec industries.

The production of asbestos is no longer confined to Quebec; there are operating mines in British Columbia and Ontario, and next year production will begin in Newfoundland. The industry today is made up of 11 companies operating 15 mines.

NAMES	LOCATION
Asbestos Corporation Limited	Beaver, King, British Canadian, Normandie (Thetford-Black Lake, Quebec)
Bell Asbestos Mining Ltd.	Thetford, Quebec
Canadian Johns-Manville Company Ltd.	Jeffrey at Asbestos, Quebec. Munro near Matheson, Quebec.
Carey-Canadian Mines Ltd.	Near Tring Junction, Quebec.
Cassiar Asbestos Corporation Limited	Cassiar, B.C.
Flintkote Mines Limited	Near Thetford Mines, Quebec.
Johnson's Asbestos Company	Black Lake, Quebec.
Johnson's Company Limited	Thetford Mines, Quebec.
Lake Asbestos of Quebec Ltd.	Black Lake.
National Asbestos Mines Limited	Near Thetford Mines.
Nicolet Asbestos Mines Limited	Norbestos, Quebec.

From its humble beginning 85 years ago, asbestos mining has grown to a $100 million a year industry. Current production is in excess of one million tons annually of which more than 95% is shipped from Canada to markets around the world.

The 'old' Helen iron mine, Michipicoten area of Ontario, 1906.

THE CANADIAN IRON ORE INDUSTRY

Its History and Development

T. H. Janes

Scientific Officer, Mineral Resources Division, Department of Mines and Technical Surveys.

Iron ore mining in Canada has had a long history marked by extended periods of little or no progress. However, the modern era, measured from the resumption of iron mining operations in 1939 at the Helen mine of Algoma Ore Properties in the Michipicoten area of Ontario, has been characterized by widespread, rapid growth and diversification. From 1886 to 1924, recorded production of iron ore in Canada was 6,620,-872 short tons valued at about $16.8 million. There were no shipments from 1925 to 1938 inclusive. Between 1939 and the end of 1961 shipments were 182,-892,239 tons valued at $1,351,325,281. Current production is from 20 mines operated by 12 companies in Newfoundland, Quebec, Ontario and British Columbia.

The 1667 to 1924 Period

The early forges and steelmaking facilities in Canada were based on local ores and local iron and steel requirements. Limonitic iron ore was known to exist in the Seigniory of St. Maurice, near Trois-Rivieres, Que., as early as 1667 and in 1733 there was one forge in operation. A number of other small plants all based on local ores and needs were built at various locations in Canada during the latter part of the eighteenth and in the nineteenth centuries. The first blast furnace in Ontario was built at Lyndhurst, north of Kingston, in 1800. The second was at Normandale in Western Ontario in 1815 and was operated by various owners until 1847. In Nova Scotia an attempt was

Published by permission of the Deputy Minister, Department of Mines and Technical Surveys, Ottawa, Canada.

ıade to produce iron in Pictou county from local ores 1829 but the product was of poor quality and not sable. In 1872, the Hope Iron Works was established the same area and a successor company, formed the ext year, continued using ore from Londonderry and cadia mines until it failed in 1883. The Nova Scotia orge Company began operations in 1879 using rought iron and scrap as raw material, installed an pen hearth steelmaking furnace in 1883 and changed s name to Nova Scotia Steel Company. A blast furace was built at Ferrona (North New Glasgow) in 888 to smelt ore from Pictou county. Through purhases of other companies and amalgamations this ompany became the present Dominion Steel and Coal orporation, Limited, in 1930. It has obtained the ıajor portion of iron ore requirements from companywned mines on Bell Island, Nfld., but predecessor ompanies had relied largely on local iron ore.

The struggling Canadian iron and steel industry uring the nineteenth century suffered from small, videly-separated markets and from competition of netal imported from England and the United States. Notwithstanding certain 'protectionist' measures, first ntroduced in 1879, Canadian production did not inrease sufficiently to satisfy the widely-scattered lomestic market and iron and steel imports continued o increase. In 1912, after having paid out $17.4 nillion in helping to establish the industry, all forms of bounty assistance by the Federal Government were vithdrawn.

The discovery in the United States of large deposits of direct-shipping hematite on the Mesabi Range of Minnesota about 1890 and subsequent development to production of mines on it greatly reduced the market for Canadian iron ore in the United States. Integrated steelworks in Ontario also turned to the Lake Superior area of the United States for their iron ore. It was primarily on Mesabi ore that Canada's two largest integrated steel companies—The Steel Company of Canada, Limited at Hamilton and The Algoma Steel Corporation, Limited at Sault Ste. Marie —based their operations as did Dominion Foundries and Steel Limited in Hamilton starting in 1951. From 1924 to 1938, all iron ore consumed in Canadian steel plants was imported, almost entirely from the head of the Great Lakes region in the United States. Interest in Canada's iron ore potential was not revived until the mid-1940's following great demands on the Mesabi ores as a result of two World Wars and a rapid increase in United States steel production, iron ore requirements and changing blast furnace blending practices.

Renewed Interest in Canadian Iron Ore

Some iron ore and steel interests in the United States recognized the foregoing problems even in pre-Second World War years but little was done to search for alternative sources of supply to Mesabi ores until after the war. Because of geographical proximity,

Mine and mill of Quebec Cartier Mining Company's Lac Jeannine operation near Gagnon, Quebec.

internal lines of transportation and a favorable political and investment climate, the attention of all major steel and iron ore merchant companies turned northward to Canada in search for new iron sources. Time has shown that this search, though far from complete, has been richly rewarding.

Nearly all of Canada's major iron ore operations are based on areas that have been long known as iron-bearing. The discovery of the Helen iron range in the Michipicoten area of Ontario was made in 1898 and within two years most of the other ranges in the area were located. It was in the late part of the last century when A. P. Low of the Geological Survey of Canada made his famous traverses inland from the east coast of the Labrador peninsula and roughly mapped what has since become known as the Labrador Trough. He noted the presence of iron formation and clearly stated its possibilities as a source of iron. It was not until 1929, when W. F. James and J. E. Gill conducted an expedition into the area and located what is now known as Iron Ore Company of Canada's Ruth Lake No. 1 ore body at Schefferville, that further attention was paid to Low's early work. In 1933, Dr. Gill headed an expedition to the Wabush Lake area, now the scene of major development of beneficiating-grade iron ore deposits.

As early as 1897, geological survey parties were convinced of the presence of iron ore in the Steep Rock Lake area, 140 miles west of Port Arthur, Ont. Large quantities of hard hematite 'float' ore were noted on the south shore of the lake but ore in place was not found. It was not until an extensive diamond drilling program was conducted from 1938 to 1941 that the large hematite-geothite iron orebodies were discovered under the lake. The property was brought to production in 1944.

Mention has already been made of the early operations in eastern Ontario, Quebec and Nova Scotia based, for the most part, on small magnetite deposits. Many of them were operated around the turn of the century and most have been re-examined in recent years, with a view to resuming production. Of them only Hilton Mines, Ltd. is producing. Marmoraton Mining Company Limited is an exception to the "long-known-deposit' rule in that it started production of iron ore pellets in 1955 from a magnetite deposit near Marmora, Ont., discovered as recently as 1949 by an airborne geophysical survey.

The occurrence of magnetite deposits on the coast of British Columbia, on the offshore islands and on Vancouver Island has been on record for more than a century. Officers of the Geophysical Survey of Canada have reported upon them since 1873. First shipments of magnetite from the Texada Island deposits were made in 1885 and intermittent shipments were made until closure of operations in 1908. Texada Mines Limited made its first shipments of magnetite from these deposits in 1952 and to the end of 1961 had exported some 3 million tons. Several other deposits have been developed, or are being developed, to production in the past decade. Most of these were discovered and examined before the turn of the century.

The Wabana iron ore deposits on Bell Islan Nfld., have been operated successfully since 1895 wh the first shipment from a surface exposure was made Halifax. For most of their history the Wabana mi have been operated as submarine mines on 'slop that now extend up to three miles under the oce floor.

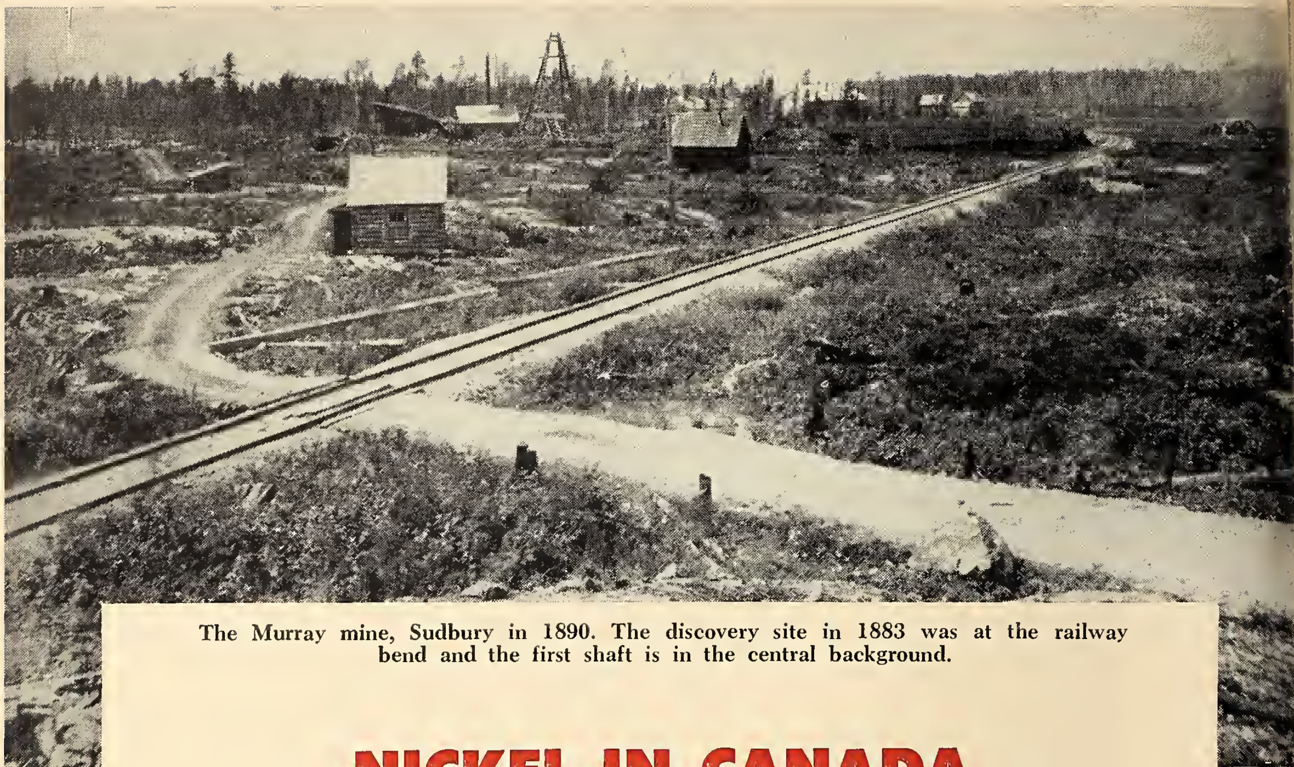
Current Developments and the Future

In addition to production at Schefferville, Ir Ore Company of Canada is developing large iron o bodies at Wabush Lake, Labrador, for initial produ tion of concentrates in 1962 at a capacity rate of million tons a year. Quebec Cartier Mining Compa made initial shipments of concentrate in mid-19 from Port Cartier, Que. Its operation at Lac Jeannin 193 rail miles north of Port Cartier, is designed to mi and concentrate 20 million tons of crude ore a year recover 8 million tons of concentrate, averaging 6 iron. Wabush Iron Co. Limited, some 85 miles nort east of Lac Jeannine but in Labrador near Iron O Company of Canada's Wabush Lake operations, is pr ceeding with a $300-million development for capaci production of 6.0 million tons of concentrate a ye with initial shipments scheduled for 1964. The thr operations will add 21 million tons a year to Canada iron ore production capacity.

Canadian iron ore shipments in 1960 and 196 were 18.2 million tons and 19.2 million tons, respe tively, valued at $175.1 million and $180.5 millio Forecasts indicate that production capacity will i crease to about 45 million tons in 1965 and to betwe 60 and 70 million tons in 1970.

Although the Canadian iron ore industry is firml established it is not without its difficulties. Canadia producers must meet severe competition in the Fre World's major steelmaking countries from producers c high-grade direct-shipping ores in other countrie Therefore, product research on direct-shipping ore and the development of properties for production c high-grade concentrates and agglomerates have becom of prime importance to the Canadian iron ore industry

Sufficient exploration and development has take place in Canada to indicate very clearly that th country's iron ore resources are very large and mor than sufficient to satisfy domestic requirements an meet export demands for many, many decades. No only does Canada possess large reserves of direct shipping ore but it also has vast reserves of lowe grade iron-bearing material that is readily amenabl to beneficiating into premium quality products. It i meaningless to place an arithmetical figure on iro ore reserves because such an estimate would amoun to little more than a guess based on geological reconnaissance, supported by what is best termed 'a relatively limited amount of diamond drilling'. They do however, amount to many billions of tons and wit continuing favorable operating conditions and cooperation between governments and companies the iron ore industry will grow and make an ever-increasing contribution to Canada's trade and economic well being.



The Murray mine, Sudbury in 1890. The discovery site in 1883 was at the railway bend and the first shaft is in the central background.

NICKEL IN CANADA 1887 to 1962

C. C. Allen

Scientific Officer, Mineral Resources Division, Department of Mines and Technical Surveys.

The history of the nickel industry in Canada almost parallels the history of engineering in Canada since 1887. The first reference to the Sudbury basin was in 1856 when A. P. Salter, an Ontario Land Surveyor, noted a strong magnetic attraction while surveying a meridian north of Whitefish Lake. Subsequent assays gave low values in nickel and copper. Nickel-copper sulphides were rediscovered in the area in 1883 during the construction of the Canadian Pacific Railway. A railway cut passed through the mineralized area and in later years the Murray mine was developed on this site. It is one of the currently operating mines of the International Nickel Company of Canada, Limited. Thus, engineering was of importance in the initial discovery of nickel in Canada and of tremendous importance to Canada's present gigantic stature in the world nickel industry.

The accompanying photograph, taken in 1890, shows the Murray mine and the site of the original discovery adjacent to the railway. The Murray discovery and subsequent ones in the area quickly gave rise to an infant Canadian nickel industry. Its life was precarious for a few years because of overseas competition from vested interests but James Riley's discovery of the importance of nickel in armament steel gave it a new lease on life. The International Nickel Company, New Jersey, was formed in 1902. The industry expanded, though not without difficulties, and in 1918 another crisis was reached. Production had expanded during the First World War to serve the armament industry and with the cessation of hostilities nickel was again in surplus. A vast research and marketing program eventually succeeded in channelling nickel into an expanding civilian market.

The International Nickel Company of Canada Limited was formed in 1916 as a wholly-owned subsidiary of the New Jersey Company and in 1928 became the parent organization. International Nickel merged with the Mond Nickel Company Limited of England in 1929 and the latter continued as a wholly-owned subsidiary.

Falconbridge Nickel Mines Limited was incorporated in 1928 upon acquisition of the Bennett claims in Falconbridge township, Sudbury area. Falconbridge was brought into production during the depression in the early 1930's and has grown continuously ever since. Currently, Ventures Limited, another large Canadian mining company, is being merged with Falconbridge. This merger will increase Falconbridge assets and give it a larger future scope. The prime founder of Falconbridge and Ventures was Thayer Lindsley,

Published by permission of the Deputy Minister of the Department of Mines and Technical Surveys, Ottawa, Canada.

eir first president, who remains a director but has rned the presidency over to Dr. H. J. Fraser.

International Nickel and Falconbridge were the ly significant Canadian producers of nickel until ter the Second World War. Since the war tremendous vances were made in the pyrometallurgical treatent of nickel sulphide ores, among which were matte otation, electrolysis of sulphide anodes, fluid-bed asting and the recovery of high grade iron ore pellets om pyrohotite containing minor amounts of nickel.

During the Second World War, prospectors for herritt Gordon Mines Limited discovered nickel ineralization in the Granville Lake area of northern Ianitoba. Exploratory work after the war indicated ommercial tonnages and values. Research on metals xtraction from the ore ultimately led to a revoluonary method for treatment of nickel sulphide ore – the hydrometallurgical process of pressurized amonia leaching followed by hydrogen reduction. The rocess, now well established, was developed by Proessor Frank Forward of the University of British Columbia. The work was sponsored by Eldon L. Brown, President of Sherritt Gordon.

The latest major expansion in the Canadian nickel ndustry was the development by International Nickel of deposits at Thompson, Man. Production plans were nnounced in December, 1956, and in March, 1961, production commenced. This great engineering proect was under the direction of R. D. Parker, Senior Vice President of International Nickel. What was originally "bush" was transformed into a modern ownsite. A 45-mile railway and hydroelectric power site were built to serve the town and plant. The plant includes a concentrator, smelter and electrolytic nickel refinery, all of the most modern and compact design. Capital costs were more than $185 million, constituting Manitoba's largest single investment.

The uses of nickel are many and widespread. It is primarily used as an alloying additive with over 3,000 nickel alloys in current use. Free World nickel consumption in 1961, by percentage of total in various alloys, as outlined by International Nickel was:

Stainless steels	34 per cent
High-nickel alloys	14 " "
Electroplating	14 " "
Nickel-alloy steels	15 " "
Foundry products	11 " "
Copper-nickel alloys	4 " "
All other products	8 " "

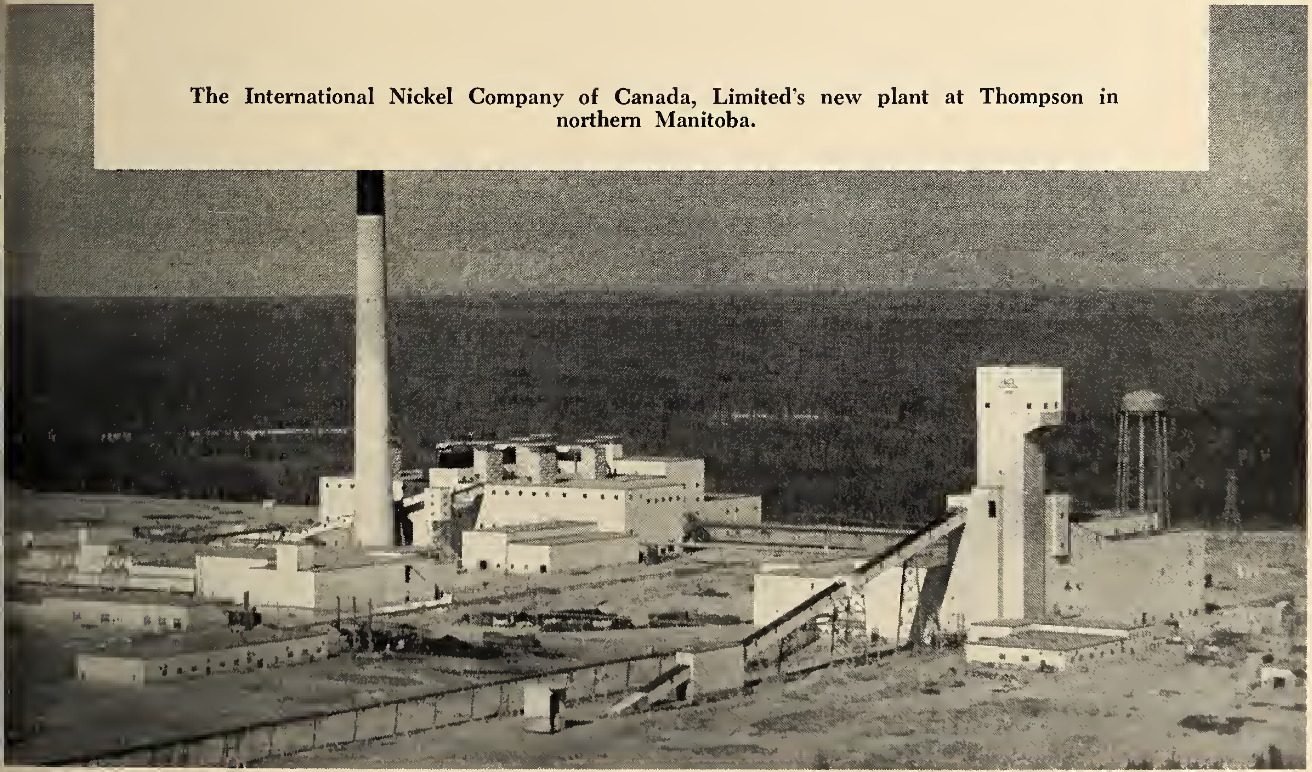
The use of nickel in stainless steel continues to show the most rapid growth.

The United States and western Europe are the largest Free World users of nickel and in 1961 accounted for about 84 per cent of its consumption. Canada used about 12 million pounds, slightly more than 2% of the Free World's total consumption.

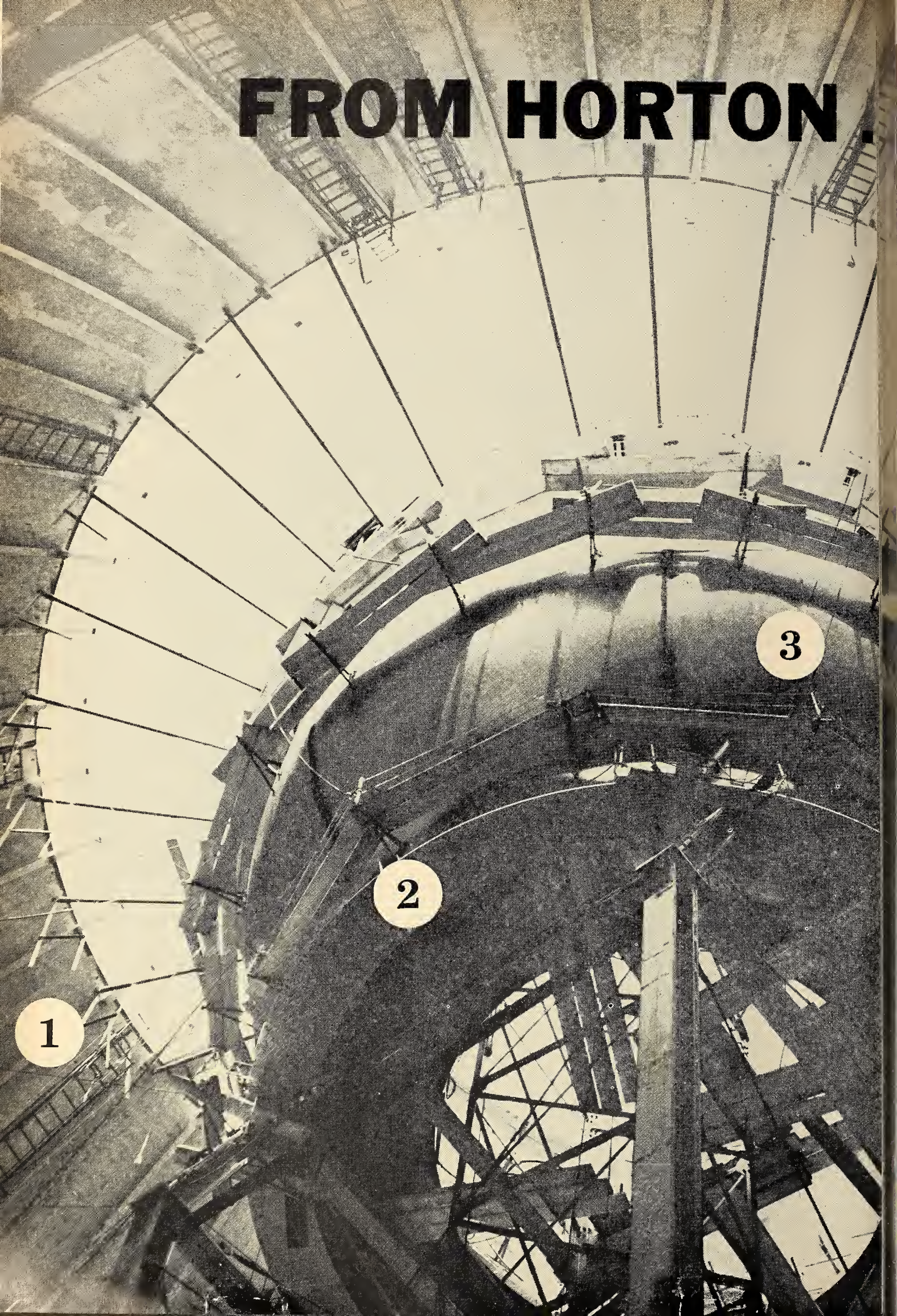
Seventy-five year ago the Canadian nickel industry had its beginning. Today, it is one of Canada's major industries and produced 237,948 short tons in 1961, more than 75% of the Free World's nickel output.

Annual production capacity in Canada is now more than 242,500 short tons of nickel. The industry consists primarily of three well-financed and well-organized companies that have grown rapidly to meet increasing demands. Future growth to meet expanding needs of the Free World's industrial economies is assured. Canada's place as the world's leading producer is premised on its abundant and growing reserves and continuing research in the processing and metallurgical treatment of nickel-bearing ores. Many engineering horizons have been reached and overcome. It is certain that more will appear to test engineering skills of Canadians and, in turn, be overcome.

The International Nickel Company of Canada, Limited's new plant at Thompson in northern Manitoba.



FROM HORTON .



Iroquois Lock looking downstream. This is only lock completely equipped with sector gates for operating. Iroquois dam to right controls level of Lake Ontario. Downstream is 90 sq. mile power pool serving international powerhouse at Cornwell.

St. Lawrence Seaway

The St. Lawrence Seaway is a monument to the vision and skills of the engineer. The Seaway made possible a 2300 mile deep waterway extending from the head of Lake Superior to the Atlantic Ocean.

About one-sixth of the total area of North America is drained by the Great Lakes-St. Lawrence Seaway system. In this area, which contains about 65 million people, there is produced nearly 80 per cent of North American steel, about half its manufactured goods and more than 40 per cent of its food.

While the development is known as the Seaway, it should not be ignored that the untapped hydro electric power potential of the St. Lawrence River had long been coveted.

The historic barrier between Montreal and the inland waters was the Lachine rapids near Montreal. This was a problem even in the days of the fur trade and small canals were dug to circumvent the wild waters. Beyond Lachine and still separating the salt water from the Lakehead were other stretches of rapids, fast water and of course the falls on the Niagara River between Lake Ontario and Lake Erie.

Among the early advocates of a Seaway was Thomas Keefer, the first President of what now is the Engineering Institute of Canada. In a series of books, pamphlets, articles and speeches Keefer advocated a deep-water passage into the heart of North America.

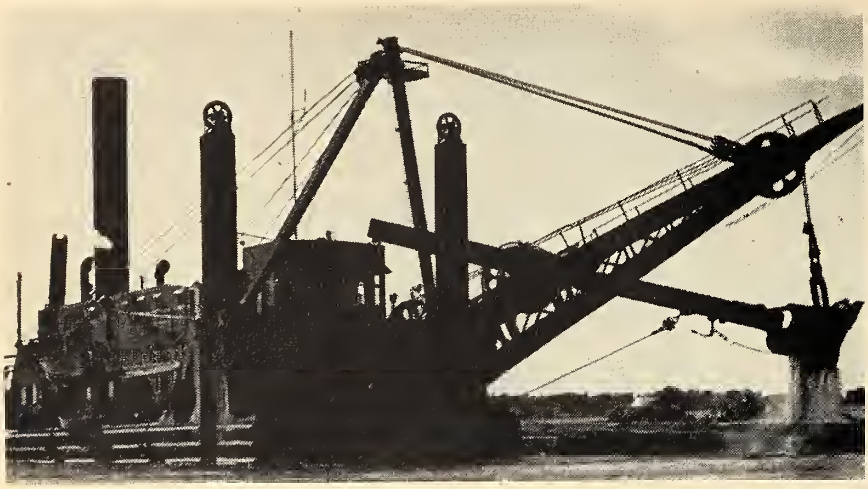
By 1904 the St. Lawrence, Soulanges and Lachine canals were completed with a 14-foot draught. Some other canals were deeper, notably those at Sault Ste. Marie.

Through the years, particularly after the First World War, increasing interest was shown both in improved navigation facilities and in power development. In 1932, the year the existing Welland Canal was opened, Canada and the United States signed the St. Lawrence Deep Waterway Treaty which defined the duties and contributions of each country. The United States Senate, however, failed to ratify the Treaty.

After the Second World War Canada forced the issue. This country told the United States that an all-Canadian project would be built if our neighbor was not sufficiently interested to participate. Subsequently a new agreement was drafted and ratified by both countries.

The waterway agreement provided for a 27-foot depth from salt water to the upper lakes.

The Hydro-Electric Power Commission of Ontario and the Power Authority of the State of New York harnessed the rapids west of Cornwall. A 90 square mile power pool was formed, and generating plants produce 940,000 kilowatts for each country.



Dipper dredge working on channel in Lake St. Francis. Some 18 million cu. yds. had to be dredged.

VITAL STATISTICS

Following are a few vital statistics taken from literature prepared by the St. Lawrence Seaway Authority.

Number of locks, 15 (8 on the Welland Ship Canal between Lake Ontario and Lake Erie, built by Canada; completed in 1932). New locks in Canada, 5. New locks in the United States, 2.

Lift of locks varies from 1 ft. to 46 ft. Length of locks 766 ft. Width of locks, 80 ft. Depth over lock sills, 30 ft.

Size of ships, 715 ft. long, 72 ft. wide. (730 ft. long, 75 ft. wide under special conditions). Speed allowed, 6 m.p.h.

Depth of channels, 27 ft. Width of channels, 200 ft. minimum. Overhead clearance at bridges, 120 ft.

Traffic flow, both ways, day and night. The Waterway is open from mid-April until early December.

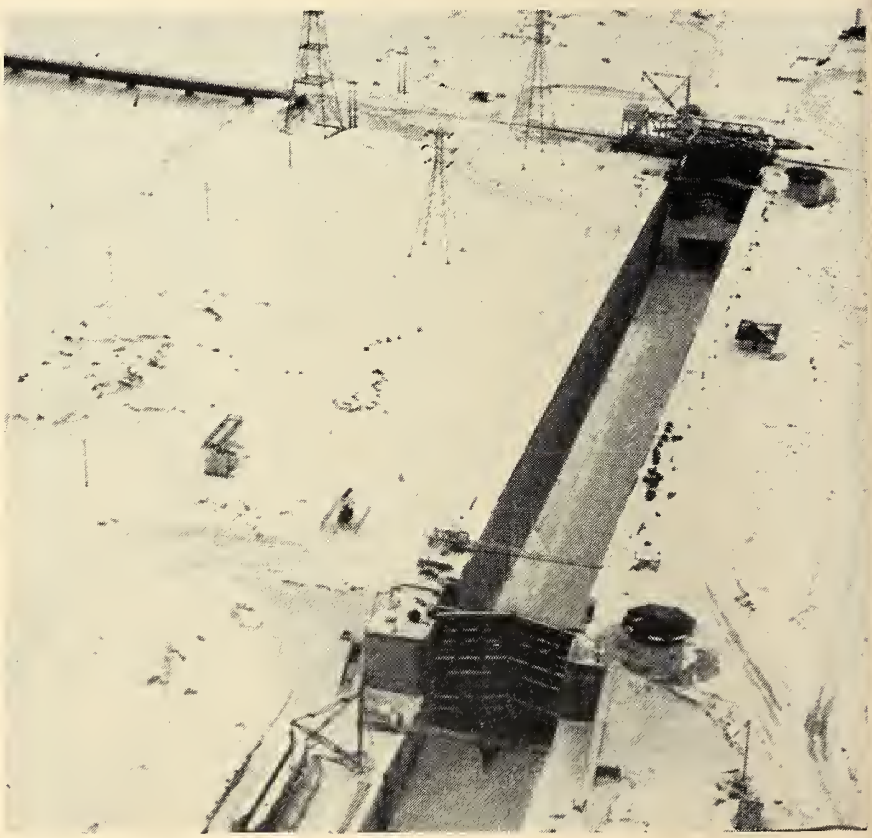
Channel excavation, Canada 56 million cu. yd., United States 35 million cu. yd. Channel dredging, Canada 18 million cu. yd. United States 5 million cu. yd. Concrete in locks, Canada 2 million cu. yd., United States 1 million cu. yd.

Largest number of workers at peak, 22,000. (Canada, United States, navigation and power).

Cost, Canada: Navigation $329 million, power $300 million, total $629 million. United States: Navigation $128 million, power $300 million, total $422 million.

THE WELLAND CANAL

In 1913 the Canadian Government undertook a project which would ultimately form part of the completed seaway. The new Welland Ship canal fourth and largest of a series of four canals built in Canada to connect Lakes Erie and Ontario, was commenced in that year. Work was suspended in the fall of 1916 but was resumed after World War I and was completed in 1932 at a capital cost of $130 million. A newer Welland canal costing some $75-100



Upper Beauharnois canal under construction. Crossing is for the N.Y. Central R.R.

View of rail-road bridge over Beauharnois canal. A new lift span had to be installed to permit navigation.

million will be needed within a few years. If the Seaway is to carry its full potential and pay for itself in 50 years, it is expected that tolls will enable Canada to build this duplicate soon enough to allow full development of traffic.

BEAUHARNOIS

It was R. A. C. Henry, M.E.I.C., then chief engineer of Beauharnois Light Heat and Power Company who made the imaginative and far sighted proposal that the difficulties of power development in the Soulange section should be overcome by the construction of a canal between Lake St. Francis and Lake St. Louis to take the full flow of the St. Lawrence.

The Beauharnois development, now owned and operated by Hydro Quebec, is one of the largest plants in Canada with an ultimate capacity of more than 2,000,000 horsepower. Located in the Soulange section it was commenced in 1929 with the proviso that the power canal would later be improved and deepened and widened to the dimensions necessary for use as a navigation channel for the Seaway. The power canal is 16 miles long and is now being dredged to a 27 ft. depth throughout. Two locks have been installed by Canada's Seaway Authority.

Plans for the construction of the seaway proper, however, involved agreement in detail between Canada and the United States, and it was not until 1954 that the men and machines on each side of the border could actually begin their huge task.

OPENING CEREMONY

The ceremony in September, 1958, at the powerhouse on the International Boundary was a tribute to the perfect co-ordination that marked the four-year construction period of the St. Lawrence Seaway

St. Lambert Lock before road and rail division completed. In foreground is Victoria Bridge. In background are the 4 piers of the Champlain Bridge under construction.

Seaway Entrance. Note Cofferdam at entrance. This portion of Jacques Cartier bridge had to be permanently raised to provide ship clearance.

and Power Project. Premier Leslie Frost of Ontario and Governor Averill Harriman of New York State jointly pressed a switch to start eight generators delivering power on a commercial basis on September 5th, the exact date set four years previously for first delivery of power and partial opening of navigation through the new locks. The opening of the complete seaway on schedule was the crowning achievement of this co-ordination between the Joint Commission, the Board of Control, the Joint Board of Engineers, the four Authorities and the many contractors and suppliers.

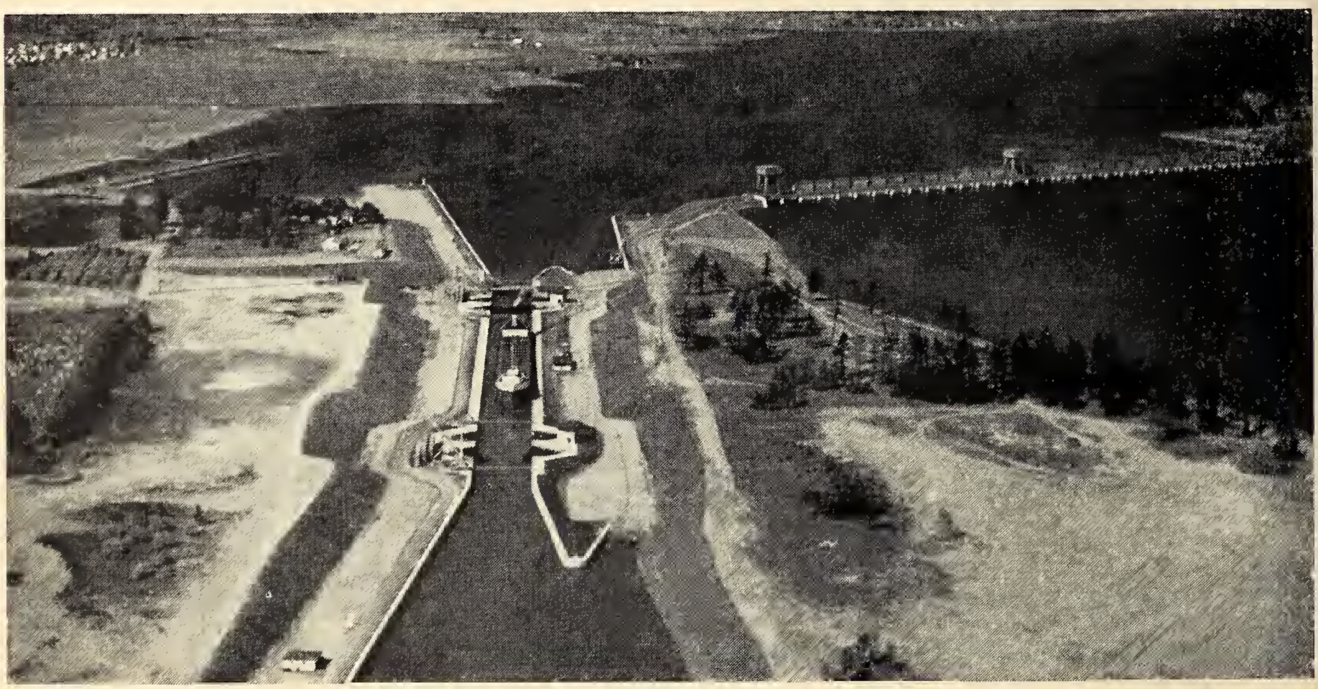
RAISING A BRIDGE

The smooth operation of the intensive four-year program was marked by many impressive engineering accomplishments. Outstanding among these was the raising of the southern half of the 2½ mile Jacques Cartier highway bridge over the St. Lawrence at Montreal harbour to provide adequate overhead clearance for seaway vessels. The roadway profile was changed by jacking the spans and building up the bridge piers on which they rested to increase the clearance by 50 ft.

NEW LOCKS

Canada has built five of the seven new locks on the seaway between Montreal and Prescott that replaced 21 on the old system. The smooth working of the gate machinery in the new locks is another notable achievement. It takes only six minutes and causes a

St. Lambert Lock under construction. Diversion span in process of erection.



minimum of water disturbance to fill or empty a lock 80 ft. wide with a usable length of 768 ft., providing a lift of 6 ft. This is half the time taken in the Welland Canal locks built some 25 years ago.

A further 33 ft. was gained by replacing one of the original deck-truss spans with a new through-truss span built on falsework on one side and slid laterally into place, pushing the old span on to falsework on the other side. Translation of the trans-channel span took place on October 20, 1957, closing the bridge to traffic for less than five hours on a Sunday morning. Jacking of the bridge was completed on July 2, 1958. The designer of the original bridge, the late Dr. P. L. Pratley, M.E.I.C., also designed this modification which fully preserves its artistic and practical value.

The two American locks were opened to navigation for ships of 14 ft. draught early in July, 1958 and by the close of navigation a total of 5289 vessels had passed through these locks and through the Iroquois Lock on the Canadian side. By year-end work on the remaining four Canadian locks, St. Lambert, St. Catherine, and the Upper and Lower Beauharnois locks was completed, with the exception of machinery installation and testing of the lock gates.

RAIL BRIDGES

Early in October 1958 a 212 ft. 1,500 ton rail-highway lift span, assembled a mile east of the upstream entrance to the Beauharnois canal, was loaded on two scows and towed on three tugs to the site of the Valleyfield railway bridge crossing the canal. After one existing span had been removed and stored on pile supports the new lift span was raised by pumping out the scows and let down to exact position on the bridge piers. Later another 212 ft. span was towed 8 miles down the canal and installed on the N.Y.C.-St. Louis rail bridge.

INTERNATIONAL POWERHOUSE

Works of the power project also have been brought into effect with notable smoothness of transition. One example of this has been the shortening of the customary dry-out period on the Canadian generators in the International Powerhouse, permitting the first two to be placed "on-line" within one week following the raising of water in the headpond.

The flooding sequence of June 30-July 5, 1958 was carried out with remarkably little dislocation of river traffic. At 4 a.m. on June 30, 1958 shipping was cut off between Cornwall and Prescott, Ont. on existing 14-ft. draught canals. At midnight stoplogs were placed in the closure structure after the last downbound vessel had cleared. At 4 a.m. July 1, gates of the Iroquois dam were opened to pass 310,000 cubic feet of water per second, then at 6 a.m. the tunnel ports of Long Sault dam were progressively closed.

At 8 a.m. on July 1 cofferdam A-1 above the Long Sault Rapids between Sheek and Barnhart Islands was placed with some 35 tons of exposive, releasing a 30 ft. wave which slowly inundated 30,000 acres of land creating an international lake 35 miles long and 5 miles wide at its widest point. At 9 a.m. the cofferdam at Ogden Island near Waddington, N.Y. was bridged.

With filling of the pool completed July 4, power production was commenced with two units on the Canadian side while navigation was resumed on July 4. By the end of that month seven units were producing power—three on the Canadian side and four on the U.S. side. At year-end eighteen units were in operation, nine in each half of the powerhouse.

A Century of Progress IN THE CANADIAN PETROLEUM INDUSTRY

R. A. Simpson

Scientific Officer, Mineral Resources division, Department of Mines and Technical Surveys.

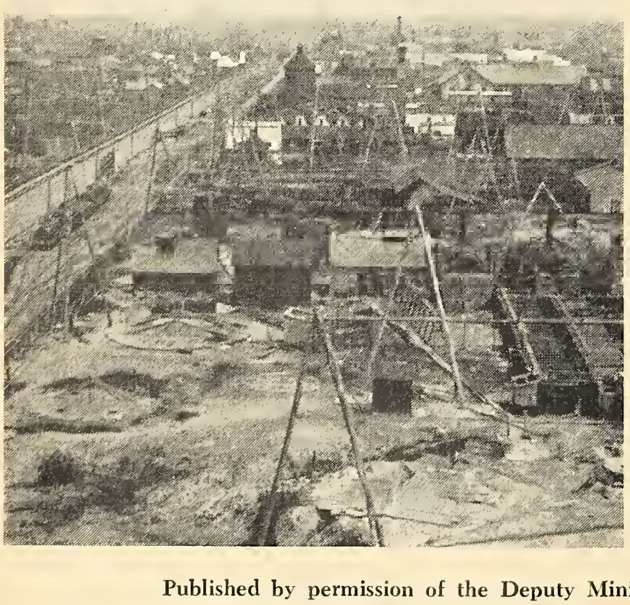
Petroleum and natural gas are among the great industrial resources of the world but that position has been gained only recently. In ancient times, petroleum was used in its raw state for such simple uses as waterproofing and for making mortar while gas seeps were revered as eternal fires. The usefulness of both resources has widened as civilization has progressed, until today petroleum is the largest single commodity in world trade and gas is making up a larger and larger share of total energy consumption by nations fortunate enough to possess it.

The first development of commercial significance in the Canadian industry occurred over a century ago, in 1858, when James Miller Williams dug a well to investigate an oil seep near Petrolia, Ont., and found crude oil in quantities sufficient not only to serve the local refinery that he constructed but for export to the United States. His contribution was recognized in 1862 at the International Exhibition in London, England, when his company won one gold medal for being the first to produce oil and another for being the first to refine oils in Canada.

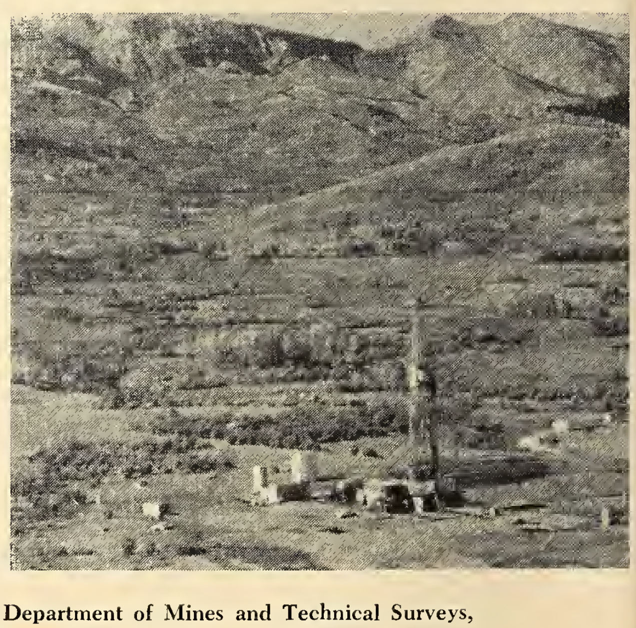
In subsequent years wells were drilled in the southwestern region of Ontario finding both oil and gas—the main oil-producing region being near Sarnia and the gas producing region nearer the Niagara River. Near Petrolia oil flows ranging up to 7,500 barrels daily were discovered. Crude oil from this area was used to produce an illuminating oil that contained sulphurous compounds. This eventually led to its being supplanted by the sweet illuminating oils from the United States but, by 1868, processes had been developed to improve the quality of the kerosene sufficiently to allow Canada to re-enter the export market. By 1870, 60% of Canadian oil products were shipped to Europe. However, in 1873, low-cost, high-quality kerosene from the United States captured the overseas market and entered Canada as well. To indicate the scale of industry in Canada at that time, about 100 refineries had been constructed and, although individual capacity was small, the Canadian oil producing and refining industry was one of the largest in the world.

Natural gas developments followed oil but until 1890 little commercial use was made of the resource. By 1891, Canadian natural gas was supplying a few small Ontario towns and, in addition, a pipeline system had been constructed across the Niagara River to carry gas to the city of Buffalo, N.Y. In spite of this, the

Petrolia, Ontario: A view showing conditions in the petroleum industry during the early period.



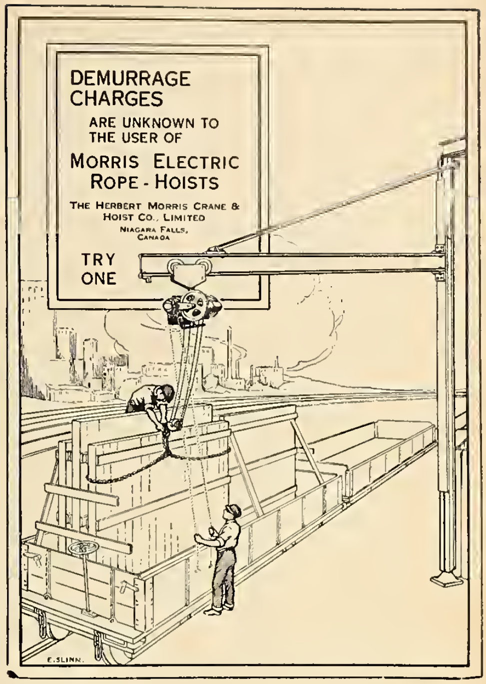
A modern portable drilling rig capable of drilling up to 15,000 feet.



Published by permission of the Deputy Minister, Department of Mines and Technical Surveys, Ottawa, Canada.

YESTERDAY....

FORTY-FIVE YEARS AGO
MORRIS WAS A MAJOR
ADVERTISER IN THE
JOURNAL OF THE ENGINEERING
INSTITUTE OF CANADA AND



A LEADING NAME IN CANADIAN MATERIALS HANDLING

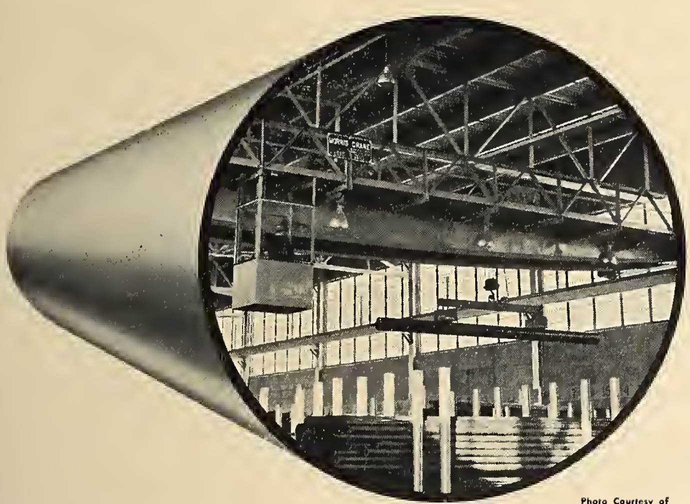


Photo Courtesy of Grinnell Co. of Canada Ltd.

MORRIS

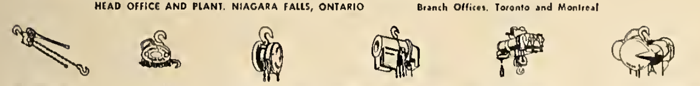
...very much a part of the picture!

When it comes to moving pipe, as the 5 Ton, 81 ft. span Morris Electric Overhead Crane shown above is doing, or moving turbines, boilers, structural steel, paper, or almost any material for industry; Morris offers the widest range of pre-tested Cranes & Hoists in Canada, and a background of nearly fifty years Materials Handling.

MORRIS

THE HERBERT MORRIS CRANE AND HOIST COMPANY LIMITED

HEAD OFFICE AND PLANT, NIAGARA FALLS, ONTARIO — Branch Offices, Toronto and Montreal



LEVER PULL-HOIST HOIST 3/4 - 1 1/2 - 3 Tons	LIGHTWEIGHT TRIPLE - GEAR CHAIN HOIST 1/4 to 5 Tons	STREAMLINED TRIPLE-GEAR CHAIN HOIST 1/4 to 20 Tons	ELECTRIC CHAIN HOIST CLASS "AW" 1/2 and 1 Ton	CLASS "F" ELECTRIC WIRE ROPE HOIST 1 to 20 Ton	CLASS "WF" ELECTRIC WIRE ROPE HOIST 1/2 to 5 Ton

TODAY

MORRIS MAINTAINS ITS POSITION OF LEADERSHIP . . .

. . . through an awareness of Canadian requirements and the skills and experience to meet those requirements. **MORRIS** now offers the widest range of pre-tested CRANES & HOISTS in Canada.

MORRIS

value of Ontario production remained less than $1 million until 1909 and reached an all time high of $7.7 million only in 1940.

After 1873, the Canadian oil and gas industry fell far behind that of the United States and had little to rejoice about for three-quarters of a century. A noteworthy contribution, however, was made by the early Canadian drillers who perfected a system of drilling using linked, wooden poles instead of rope or steel cable, a drilling tool consisting of a bit and "jars", and a walking beam to transmit power from the engine to the poles. A quotation from Neuburger & Noalhat will serve to illustrate the point: "Imported into Galacia (now Poland) in 1883 by Mr. MacGarvey the Canadian machine was not long in superseding all other systems of drilling thanks more especially to the rapidity of its boring, which was quite a revelation to contractors and owners of wells in that country." The Canadian system shared a large portion of the spotlight of drilling until the rotary drill was perfected.

The second significant development in the Canadian industry was the discovery of oil near Leduc, Alta, in 1947, almost a century after the initial Ontario discoveries. This marked the emergence of Canada again as a major oil-producing and oil-refining country and paved the way for finding the large reserves of oil and gas in western Canada upon which the modern industry is based.

One of the most obvious measurements of industry progress is production. Until 1929, when "naphtha" production from the Turner Valley gas cap became significant, annual output of oil remained below one million barrels valued at $3.7 million and gas output was a maximum of 28 billion cu. ft. valued at $10 million. The discovery of the oil pool in the Turner Valley field in 1933 resulted in total Canadian output of oil being raised to the 10 million barrels-per-year range during the 1941-44 period. The potential of the field declined after that and Canadian output of oil and gas lessened until the Leduc discovery. The table below of annual production will serve to illustrate the tremendous strides made since 1947.

The main producing areas of oil and natural gas lie in western Canada where significant markets exist but the large consuming centres are located far outside the producing regions, thus presenting major problems of transportation. The most practical and economical overland method of transportation is by pipeline; hence extensive systems of oil and gas pipelines have been constructed to gather and transport these products to markets.

The two main components of the oil transportation system are the Interprovincial Pipe Line Company Limited with its wholly-owned subsidiary in the United States, Lakehead Pipe Line Company Inc., and the Trans Mountain Oil Pipe Line Company. The Interprovincial-Lakehead pipeline stretches from Edmonton eastward across the Prairies to Gretna, Manitoba, where it enters the United States. It continues eastward, south of Lake Superior, across the Straits of Mackinac to the St. Clair River where it crosses to Sarnia and extends eastward to Port Credit. The length of this route is 1,900 miles. The capacity of the line varies from 121,000 to 434,000 barrels daily. The Trans Mountain pipeline begins at Edmonton and extends westward through the Yellowhead Pass and southward via Kamloops to Vancouver. A lateral line runs south to serve three refineries in the United States Puget Sound region. The length of this line is 787 miles and its capacity in Canada is 250,000 barrels daily. A new smaller oil pipeline, constructed in 1961, carries crude from the Peace River area of British Columbia south to the Trans Mountain pipeline at Kamloops. In total at the end of 1961 there was over 9,000 miles of oil pipeline operating within Canada.

Gas pipeline networks are of most recent vintage than oil lines, with three main transmission lines forming the backbone. Two of these transmission lines, Trans-Canada Pipe Lines Limited and the Alberta Natural Gas Company, are supplied with gas gathered in Alberta by Alberta Gas Trunk Line Company Limited and delivered to the provincial boundary. The Trans-Canada pipeline begins at Burstall, Sask., near the Alberta border and stretches eastward across the Prairies to the Lakehead, arches northward through the clay belt region of Ontario, south to Toronto and then east to Montreal, a total distance of 2,340 miles. A lateral line runs south from Winnipeg to serve an export market in the United States. The Alberta Natural line, along with the Alberta Gas trunk feeder system and the line in the United States to California, was completed only in 1961 and is the largest diameter (36 inches) pipeline in Canada. The third main gas transmission line is that of Westcoast Transmission Company Limited which carries gas from the Peace River area of British Columbia and Alberta to the interior region of British Columbia and the Vancouver area as well as for export to the United States. In total there are about 34,000 miles of gas pipeline in Canada with about 4,000 miles being gathering lines, 11,500 miles transmission lines and 18,500 miles distribution lines.

Important phases of industry operation are the processing facilities to serve both the oil and natural gas industry. Canada has one of the most modern petroleum refinery industries in the world and fourth in size after the United States, the Soviet Union and Britain. At the end of 1961 the industry's capacity to refine crude oil was over 960,000 barrels daily after allowance for refinery shut-downs. On a stream-day basis, it is well in excess of a million barrels daily. Natural gas processing, too, has assumed significant proportions in recent years. Thus at the end of 1961 installed plant capacity was over 3,200 million cu. ft. daily producing some 2,700 million cu. ft. of pipeline gas, over 12,000 barrels of propane, 10,000 barrels of butane, 50,000 barrels of condensate and 4,000 tons of sulphur daily.

Such is the petroleum and natural gas industry in Canada at the beginning of 1962. The outlook for 1962 and the future remains bright.

ANNUAL CANADIAN PRODUCTION OF OIL AND GAS, 1947-1961

	1947	1950	1953	1956	1959	1961
Oil						
Millions of bbl	8	29	81	172	190	235
Millions of $	20	85	201	406	435	510
Gas						
Billions of cu. ft.	53	68	101	169	417	646
Millions of $	13	6	11	17	40	64

THE STORY OF THE ENGINEERING INSTITUTE OF CANADA 1887 TO 1962

The following story does little more than highlight the chronology of the Institute on its 75th Anniversary. The full story of the Institute is an absorbing one, filled with the excitement of a growing nation. To celebrate the 75th Anniversary of the Institute, a complete history is being prepared.

THE DEVELOPMENT of Canada and the work of the engineer are impossible to separate. During the 17th and 18th centuries French engineers were active in this country, with most of their efforts being directed toward the construction of fortifications and other military installations.

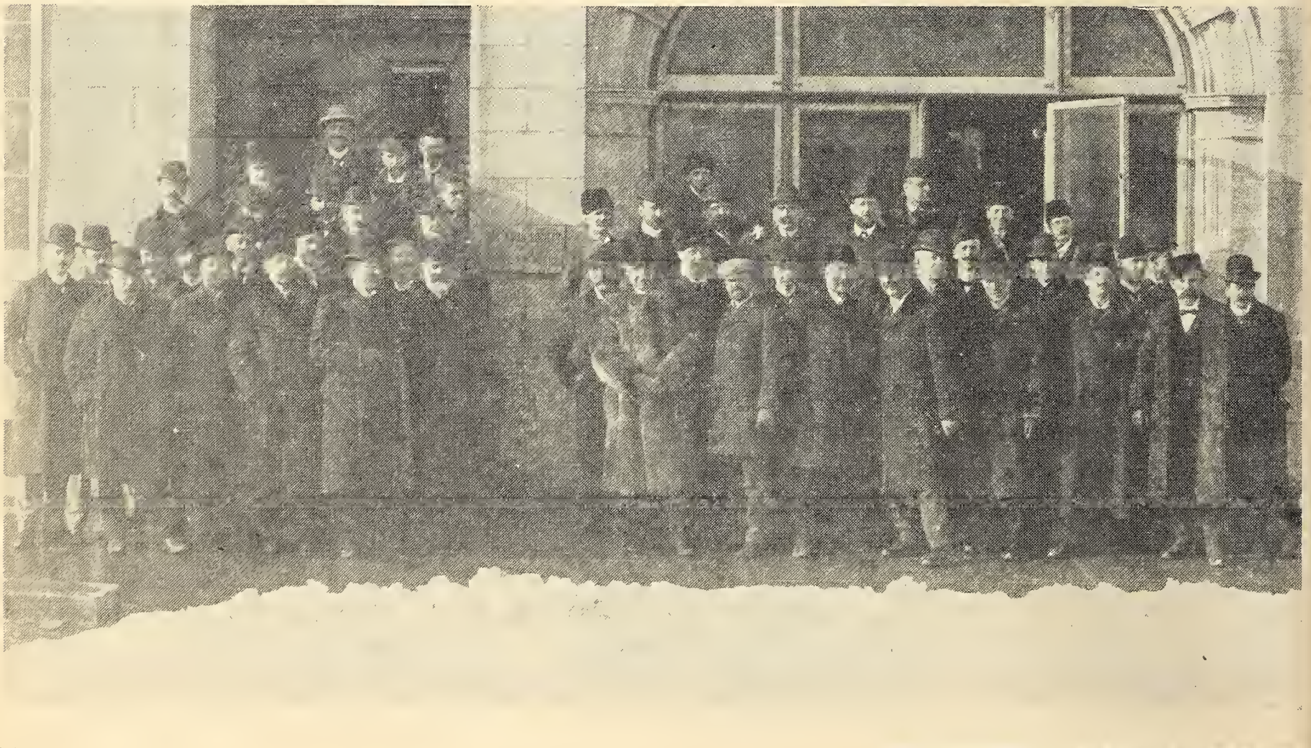
Eventually the French were succeeded by British military engineers who were concerned not only with fortifications but also roads, canals and other public works.

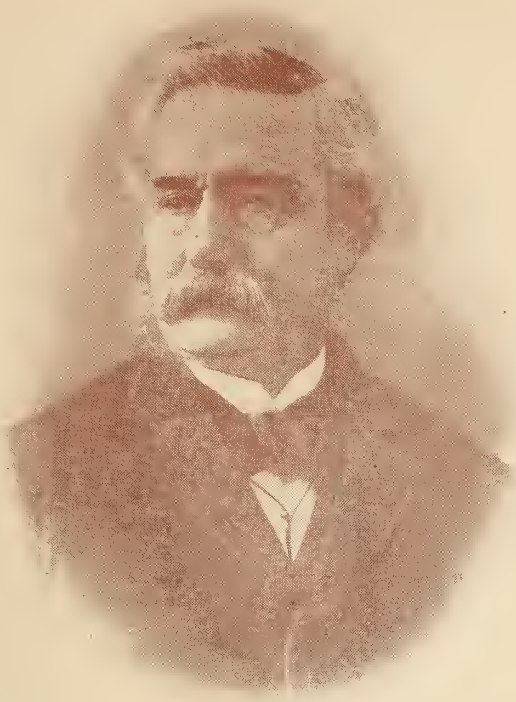
Soon the shift from military to civil engineering was almost total. The forging of a nation required engineers of vision and skill.

Many of these engineers gave serious consideration to the formation of a learned society to suit their needs. Such consideration was given impetus by Confederation and the subsequent building of the Canadian Pacific Railway. Gradually authorities at the universities of Toronto and McGill realized the importance of having training facilities for engineers, and the advantages of having an association with which to co-operate.

One concrete effort was made in Ontario in May,

Canadian Society of Civil Engineers, Annual Meeting 1901





THOMAS C. KEEFER
C. M. G.

First President
1887

1880, by E. W. Plunkett, a prominent engineer of Irish extraction. Plunkett contacted his fellow engineers regarding the formation of an engineering organization, and had introduced to the Legislative Assembly of that province "an act respecting civil engineers."

This died aborning, however, when it failed to arouse sufficient support either among the legislative or Plunkett's fellow engineers.

In spite of this, interest continued to grow. Serious discussions were held among engineers in Ontario and Quebec. Many of these later became officers and prominent members of the Society which to them was still a dream. Among them were Alan Macdougall, C. E. W. Dodwell, Thomas Keefer, Sandford Fleming, J. L. P. O'Hanly, Samuel Keefer and Kivas Tully.

Matters came closer to a head in February, 1886, when Macdougall, over his own signature, issued a circular advocating the formation of an association. This resulted in several meetings being held in Toronto, Ottawa and Montreal. Probably the most important of these meetings was held in March at the Harbour Commissioner's office in Montreal. At this meeting the following resolution was passed:

"That a society of engineers in Canada be formed comprising all branches of engineers, and that a committee be appointed to meet the other committees of engineers from other cities, and then to arrange and form a preliminary constitution, which form of constitution shall be sent around to those gentlemen who send in their names as being willing to form such a society; and that each gentleman present be requested to forward the names of engineers and their addresses to the local secretary."

A Montreal committee then was appointed to draft a constitution for the proposed society. Within a few weeks similar meetings were held in Ottawa and in Toronto at which the draft constitution was discussed and amended.

Another meeting of the Montreal committee was held on November 11, 1886. Its members considered a printed constitution which, since spring, had been prepared and amended by correspondence among the Ottawa, Toronto and Montreal committees. A provisional committee formed to revise the constitution and to establish the association consisted of: Col. C. S. Gzowski, Kivas Tully, W. T. Jennings, Alan Macdougall, Thomas Keefer, H. F. Perley, W. P. Anderson, R. Surtees, H. T. Bovey, John Kennedy, P. A. Peterson and P. W. St. George. Mr. Macdougall was appointed provisional secretary.

Four other meetings were held in the next three months. During these meetings 288 members were elected, and the decision was made to call the organization the Canadian Society of Civil Engineers.

The first annual meeting was held February 24, 1887, and at this time it was decided to apply to the Dominion Government for a charter. The charter was carried through Parliament by one of the Society's vice-presidents, Walter Shanly, M.P., and it received Royal sanction on June 23, 1887.

The first President was Thomas Keefer of Ottawa. Besides Shanly, the other vice-presidents were Casimir Gzowski, Toronto, and John Kennedy, Montreal. The secretary-treasurer was Henry T. Bovey of Montreal.

The objects of the Society were *"to facilitate the acquirement and interchange of professional knowledge among its members, and more particularly to promote the acquisition of that species of knowledge which has special reference to . . . engineering, and further, to encourage investigation in connection with all branches and departments of knowledge connected with the profession."*

These broad aims have remained unchanged.

The Early Years

The Society was healthy from its infancy. The

original membership of about 300 doubled in 10 years, and by its 30th anniversary there were about 3,000 members.

When it was decided that headquarters should be in Montreal, accommodations for the meetings were provided by McGill University. By 1890, the growth and health of the Society made it necessary and possible to lease rooms. The Secretary's office and the library were moved to the upper floor of the Bank of Montreal building at the corner of Mansfield and St. Catherine Streets, just two blocks south of the present headquarters.

In 1899 the size of the Society made it necessary to buy and renovate a house at 977 Dorchester Street. These quarters sufficed until 1913 when the present building at 2050 Mansfield was purchased and enlarged.

It was obvious that because of Canada's awkward geography, all members could not take full advantage of a centralized Society. For this reason the formation of local Branches was authorized, and provision was later made for districts and provincial zones.

The first Branch was formed in Toronto in 1890; the second was formed in Cape Breton in 1905. The Cape Breton Branch appears to have been discontinued, but was formed again in 1921. By 1912 there were Branches in Quebec City, Winnipeg, Ottawa, Vancouver, Kingston and Victoria.

The First World War

The years of the First World War were difficult ones for the Society. Almost one third of its total membership at the beginning of the war served in the Allied Forces. Despite decreased revenues the Society remained active, but only by determined retrenching.

In spite of this, Council remitted the fees of all members serving overseas, and established a modest fund for their families.

Council offered the co-operation of the Society to the Government, and urged that engineers serve in units where they could make use of their professional knowledge.

Society to Institute

Even before the end of the 19th century increasing interest was being shown in a less restrictive term than "Civil" to describe the Society. This led to the formation of four engineering sections in the Society: general, electrical, mechanical, and mining.

Agitation along these lines increased during the latter part of the First World War and, by Act of Parliament effective April 15, 1918, the name of the organization was changed to The Engineering Institute of Canada.

New By-Laws were prepared, providing for more complete Branch organization and representation. The Engineering Journal was established as the official publication of the Institute, and a full-time Secretary was appointed.

Because of these actions the membership resumed its earlier growth pattern, and the Institute's activities were met with renewed enthusiasm.

At the first General Professional Meeting of the Engineering Institute of Canada held in 1918 in Toronto, President H. H. Vaughn observed that one of the motives behind the change in name and in organization was the desire *"to unite all engineers in Canada, to whatever branch of the profession they may belong, in one society."*

Eleven more Branches were formed during the next three years, and the membership increased from approximately 3,000 to nearly 5,000.

Professional Status

The reorganization was barely completed when the question of legislation regarding professional status was again brought up, this time in August, 1918, at the Second Professional Meeting of the Institute at Saskatoon, when the subject was ably discussed in a paper by F. H. Peters, then of Calgary. At that time provincial legislation was being suggested in Manitoba, Saskatchewan and Alberta. The expressions of opinion at that meeting were in favor of action by the Institute in order to promote uniform legislation in all the provinces.

At the following Annual General Meeting in Ottawa in February, 1919, a committee was appointed, under the chairmanship of C. E. W. Dodwell, to draw up a model act for consideration in the proposal of provincial enactments. This was done, and when submitted to the corporate membership for ballot in July, 1919, met with general approval. The Institute Council accordingly endorsed the model act, and passed it to the Branches and provincial divisions for suitable action in their respective provinces. During 1920, provincial acts based on this model were obtained in British Columbia, Quebec, Manitoba, Alberta, New Brunswick and Nova Scotia. By 1923 similar legislation had been obtained in all the provinces except Prince Edward Island and Saskatchewan. An act was obtained in the latter province in 1930.

It is perhaps unfortunate that the relations of The Institute (a voluntary body) with the new Associations (provincially constituted bodies having compulsory membership), could not have been defined from the outset, for it soon became evident that such questions as the duplication of fees and the diversity of standards for admission as between the associations and The Institute, and also between the associations themselves, would have to receive consideration. On the invitation of The Institute Council in December, 1925, a conference of delegates to the provincial Professional Associations was held in Montreal in February, 1926. The principal item on the agenda of this meeting was co-operation with the Engineering Institute of Canada. The seven associations then existing were represented, and the delegates left with a resolution recording the sense of close association developed by the conference and their appreciation of the courtesy extended to them by The Institute.

In the following year, an endeavor was made by the Council of the Institute to interest the governing bodies of the various provincial associations in a movement to bring about substantial uniformity in the requirements for admission by examination of the several professional associations and to the Institute. The desirability of such a joint action was one of the topics considered at the first Plenary Meeting of the Council of the Institute held in October, 1927, at which a standing committee was set up to study this and other problems involved in co-ordinating the activities of The Institute and the several associations of Professional Engineers. This committee continued to function until 1931 in an effort to obtain joint action with the associations. It was then found desirable for the Institute representatives to stand aside, following representations that the associations should first come to an agreement among themselves. At this stage the

matter rested for a time, awaiting further action by the associations. Meanwhile the Council of the Institute again expressed its desire to co-operate with the associations in furthering the best interests of the profession throughout Canada.

During 1934, the Council received communications from the Winnipeg, Halifax and other branches, making suggestions for co-operation with their local provincial associations. Before definite action could be taken, however, the subject became the chief matter of debate at the Annual General Meeting of the Institute in February, 1935, with the result that a Committee on Consolidation was formed under the chairmanship of Gordon McL. Pitts. That committee, after two years of strenuous work, prepared a series of proposals for the amendment of the Institute by-laws, defining the lines along which, in the committee's opinion, the Institute could best co-operate with the associations. These amendments, however, did not carry when submitted to ballot.

Between 1940 and 1957 the Institute entered into agreements with the Corporation of Professional Engineers of Quebec and with the Associations of Professional Engineers of Nova Scotia, New Brunswick, Manitoba, Saskatchewan, Alberta and Prince Edward Island.

During the early 1950's interest was regenerated in the attempting to arrive at a workable form of co-operation. By 1954 the Dominion Council asked that a national committee be formed to study a "Plan of Unity." The Canadian Institute of Mining and Metallurgy and the Chemical Institute of Canada were both invited, but declined to participate at this stage.

At its annual meeting on May 24, 1957, at Halifax, the Dominion Council resolved to adopt eight basic principles for confederation. A report containing these principles was discussed at the E.I.C. annual meeting in Banff later that year.

Subsequently, committees of the Insitute and of the Dominion Council (now the Canadian Council) were formed to investigate in greater detail the matter of confederation. By the summer of 1961, the final report of the Engineers' Confederation Commission was received by the Annual Meetings of the E.I.C. and the Canadian Council. Both bodies authorized their Executive Committees to study the report and to discuss it with the Executive Committee of the other body in an effort to come to an agreement about the report.

The Depression

The Depression years were difficult ones for the Institute. Like so many other organizations it felt the economic hardships of the decade. Both membership and revenue declined, and a substantial proportion of the members were without jobs. Council quickly recognized this condition and instituted a Non-Active List which, at one time contained nearly 700 names. During these difficult years a number of Branches inaugurated programs to assist members in financial stress by collecting and distributing local funds.

The Second World War

In contrast to the situation during the First World War, the Institute actually gained strength during the Second World War. Contributions in time, effort and money were made by the Institute to the general war effort, and in particular to the technical phases.

Late in 1938, at the request of the Department of National Defence and in co-operation with the Canadian Institute of Mining and Metallurgy and the Canadian Institute of Chemistry, the Institute began compiling a register of technically trained men. In 1939 these records were turned over to the Voluntary Service Registration Bureau.

As during the First World War, fees were remitted for members on active service overseas, and for other members resident in combat areas. In spite of this, the financial structure of the Institute remained sound. This was affected in a slight degree in 1944 when the Engineering Journal met with some restrictions on its supply of paper.

Committees increased in importance and in interest and exhaustive Presidential visits contributed to sustained activity in all Branches.

The Employment Service of the Institute had several slack years, due mainly to regulations covering the placement of engineers. But by 1944 some engineers were returning to civilian life and the tempo of the Institute picked up again.

The Post-War Decade

The years immediately following the Second World War brought both growth and growing pains. By 1948 the membership finally topped the 10,000 mark. This represented an increase of almost 1,000 a year since the end of the war. All headquarters facilities were strained to meet the demands of this increase.

Engineering Institute of Canada, Western General Professional Meeting, June 7th to 9th, 1928

The Engineering Journal was troubled by paper shortages through 1947. Paper that became available was more expensive than it had been, and other production costs increased sharply. In 1949, for the first time since its inception, the advertising revenue of the Engineering Journal met the full cost of its publication.

In the decade there were no spectacular advances between one year and the next. Only a comparison between 1945 and 1955 shows the true conditions.

In 1945 the membership was just above 7,000. By 1955 it had surpassed 16,000. The number of Branches increased each year and by 1955 totalled 49, compared with 26 a decade earlier. Revenues reached new peaks—so did expenditures.

It was obvious now, though, that post-war days of automatic expansion and prosperity were coming to a close. Growth continued, but it was slower, and was achieved with greater difficulty.

Into the '60s

The Papers Committee was replaced essentially by the Committee on Technical Operations which was planned to solicit and to contribute technical information from and to all levels. CTO now was responsible for the expanding technical activities, particularly in its early stages, at the Annual Meetings.

In 1957 two important additions were made to the Institute's publications. Transactions of the E.I.C. was resumed after a lapse of many years. For the first time a yearly magazine entitled Engineering Careers in Canada was published. This was designed to outline the requirements and the opportunities existing in various engineering fields to students.

In the same year Council authorized the formation of three new committees: Policy; Property; and Student Policy.

Membership surged again in 1959 when net increase of 1,650 brought the total to more than 20,000 for the first time in the Institute's history.

During these years of consolation it became evident that certain facets of the Institute's activities required greater attention, and that the mechanics of government needed some streamlining.

To assist in the latter, Council approved the formation of the Executive Committee of Council. The Executive Committee was authorized to deal with greater despatch with matters not requiring Council attention. Council also encouraged the formation of the Committee on Membership and the Committee on Branch Operations, both of which were designed to ease communications among members and to increase participation.

The Committee on Technical Operations stepped up its activity. Its aim is to have representation from each Branch so that a strong two-way flow of technical information can be established.

Among the most significant activity of the Institute in the early 1960's was the increase in technical meetings. These took several forms: regional meetings covering a variety of topics; regional meetings geared to one theme; joint meetings having a strong single theme with sister societies.

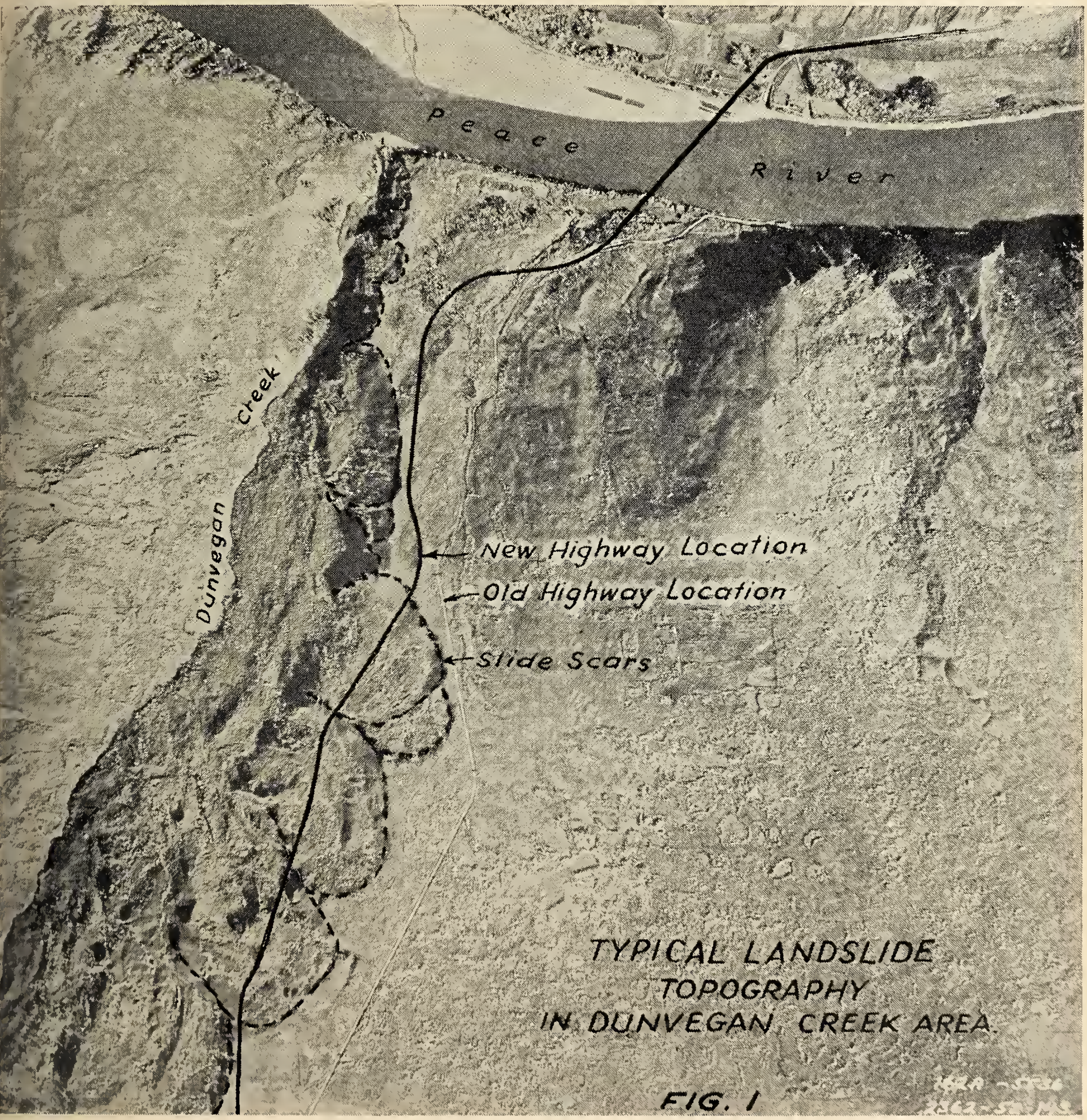
And similar to the situation which existed immediately following the Second World War the Institute found itself troubled by expansion pains as increased membership and enthusiasm strained existing facilities.

LANDSLIDES IN OVER-CONSOLIDATED CLAYS

R. M. Hardy, M.E.I.C., *E. W. Brooker*, M.E.I.C., *and W. E. Curtis*, M.E.I.C.

MANY OF THE RIVERS and streams in northern Alberta, the 'eace River block of northeastern ritish Columbia and the southern ortion of the Yukon have cut through hale deposits which have been highly onsolidated by the weight of glaciers nany hundreds of feet thick. The opography of the valleys indicates hat they have formed by sliding of he valley banks in recent geological time, and active slides exist at many locations. The shales presently exist under greatly reduced overburden pressures as compared to the loads they have carried in their earlier geological history, and the evidence is that they are still in a state of rebound under these reduced loads.

Much of the material forming the valley banks in the area under consideration is fine grained sedimentary clay-shale formed by the consolidation of clays and silts. These soils often have a laminated or thinly stratified structure as well as an argillaceous composition. Geological evidence indicates post depositional glaciation. The overburden pressure caused by huge masses of glaciers has been the principal shale forming process. A significant characteristic of certain strata in these deposits is that under



conditions of reduced overburden pressures and availability of water in the form of subsoil seepage, they revert to clays of medium to high plasticity, and assume the physical characteristics of highly overconsolidated clays. The evidence is that in the rebound process the soil mass becomes fractured, or fissured, due to changes in the internal stress conditions, and these fissures frequently provide access for subsoil seepage which hastens the process of deterioration of the shale.

Mineralogically these clays contain a comparatively high percentage of montmorillonite type clay mineral. This has the property of taking water into its molecular structure to an extraordinary degree if moisture is available and the soil is at a reduced overburden pressure. Under these conditions the shale reverts to a clay of medium to high plasticity and in the process is capable of exerting high swelling pressures. In taking up moisture such clays show a volume increase, or if confined exhibit considerable swelling pressures. The matter of swelling and swelling pressure has been the subject of considerable recent investigation. It has been shown that the major influencing factor are moisture, soil density, soil structure and mineralogical constitution.[3]

Particularly along the river valleys in the area under consideration, this deterioration of the soil appears to be actively progressing, with the result that the stability of the banks is gradually decreasing and at many locations the factor of safety against movement is very close to unity. Engineering construction in these valleys, such as road and bridge work, frequently produces change in the stability conditions sufficient to precepitate major earth movements. Experience to date in the area has shown that it is very difficult to determine by conventional subsoil exploration methods where such instabilities will develop. Experience has also shown that conventional methods of stability analysis are inadequate to accurately assess the stability of these slopes as they exist naturally or as they may be modified by engineering works. In recent years engineering works in these areas have been seriously damaged by such earth movements, In some cases the slides have been of minor consequence, but in others they have resulted in disastrous and expensive damage.

In recent months comprehensive investigations have been undertaken at two locations where major instability has developed incidental to road and bridge construction. This paper describes for these two sites the conditions encountered and the investigations made; shows the inadequacies of conventional methods of stability analyses when applied to these conditions, and presents a modification to the conventional effective stress stability analysis which appears to permit a more accurate assessment of the stability conditions to be made. The significance of the modified stability analysis in the design of corrective measures to improve the stability conditions is also discussed.

Dunvegan Slide

The Province of Alberta main highway No. 2 connecting the City of Grande Prairie and the town of Peace River in northwestern Alberta crosses the Peace River at Dunvegan. For many years a ferry was in operation at the crossing. During the years 1958 to 1960 a new suspension bridge was built at the crossing.[7] At this location the valley of the Peace River is about 700 ft. deep, and in the interests of improving the grades on the highway out of the valley on the south side a new location was selected along the Dunvegan Valley. This is a steep "coulee" type of valley extending back about seven miles from the Peace River and in the bottom of which flows Dunvegan Creek.

Aerial photographs (Fig. 1) of the area showed the new highway location crossed a series of old landslides, but there was no evidence of these being active in recent years. It is impossible to locate a satisfactory alignment for a road out of this valley from the new bridge without crossing old slide area. The new alignment along Dunvegan Valley involved several substantial cuts and fills. At the site of the slide the road embankment required a fill with a maximum depth of approximately 100 ft. The construction of this embankment was commenced in the fall of 1958 and a maximum depth of fill of 70 ft. was placed before the freeze-up. Construction was continued starting about May 1, 1959.

On May 19, 1959, cracks were noticed on the ground surface below the new embankment. These became more extensive during the following four days and on May 23 a rapid movement developed. The top of the slide cut through the top of the new road embankment against the natural ground, and initially extended to a toe in a drainage trench about 12 ft. deep being constructed about 900 ft. to the west. Within a few hours the instability had extended down the full slope of the valley bank to the creek bed, a distance of about 1600 ft. west of the road embankment.

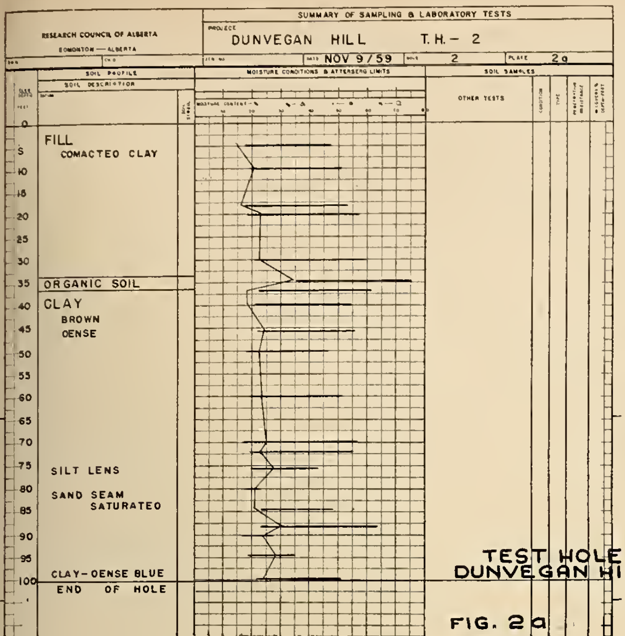
At the crown of the slide the road grade dropped vertically about 70 ft. At the north flank of the slide area there was a vertical displacement of some 30 ft., and the toe of the slide dammed the creek to a depth of about 30 ft. The surface within the slide area was broken by a network of cracks as much as 3 ft. wide and exceeding 20 ft. deep. The slide covered an area of about 50 acres and involved a movement of some four to six million cu. yd. of soil.

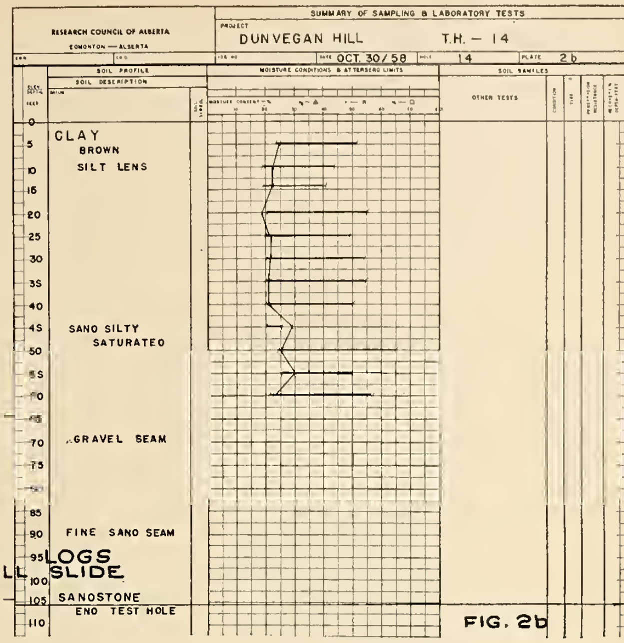
Site Investigation at Dunvegan

Previous to construction of the new highway up the valley a considerably greater than normal number of test holes were put down along the new alignment. Some 60 test holes were drilled extending to depths of from 50 to 150 ft. These borings showed the soil to be medium to highly plastic dark brown and dark grey inorganic clays interbedded with silt and silty sand seams overlying a soft sandstone bedrock. Some free water was encountered and where it occurred systematic records of the water levels were made. Of about 30 test holes placed in the immediate slide area, free ground water was observed in 15. These ground water levels ranged between 12 to 70 ft. below the ground surface. There was no consistency found between water levels in adjacent test holes. At no time during the observations preceding the slide were any significant artesian pressures recorded.

Standard penetration tests were made at intervals during the initial exploration. Blow counts from these tests ranged between 30 to 150 blows per foot. A large number of liquid limit, plastic limit and moisture content tests were made. The results of these tests showed the clay to exist in general at moisture contents close to the plastic limit. Figs. 2a & 2b shows the logs of test holes 2 and 14 and these are typical of all the test hole logs from the initial boring program. It will be noted that both these logs show several "bulges" in the natural moisture content profiles. However, the liquidity indices are all comparatively low. Artesian pressure was encountered at a depth of about 25 ft. in a sand seam in test hole 14. The maximum pressure recorded from this zone was about 17 ft. and this was the greatest recorded in any of the initial test holes.

Following the slide some 60 additional test holes were drilled. These holes were located adjacent to the slide area and on a proposed realignment. It was impossible to move drilling equipment onto the active slide area. Penetration resistance tests were run at about 5 ft. intervals, natural moisture content samples were taken at 2 ft. intervals and undisturbed 3 in. Shelby tube samples were





TEST HOLE LOGS DUNVEGAN HILL SLIDE

FIG. 2a FIG. 2b

taken at about 5 ft. intervals in these test holes. The laboratory testing program included natural moisture content and limit determinations, unconfined compressive strength tests and a limited number of consolidation tests. In addition, a series of consolidated undrained triaxial compression tests with pore pressure measurements were run.

The logs of these additional test holes in all cases were very similar to those from the pre-slide borings. The range of the penetration resistance values and the laboratory test results are shown in Table 1. The results of the triaxial compression tests are shown on Fig. 3(a), and of the consolidation tests on Figs. 4(a) and 4(b).

TABLE I.

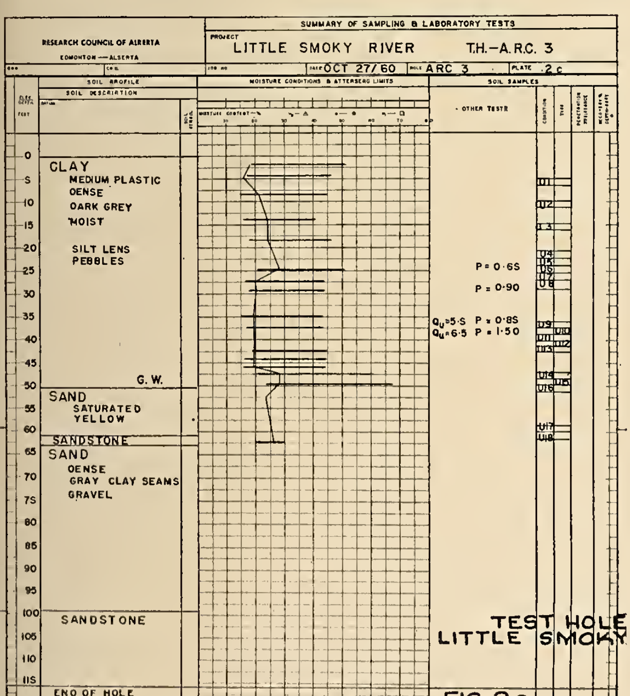
Summary of Unconfined Compressive Strength Tests

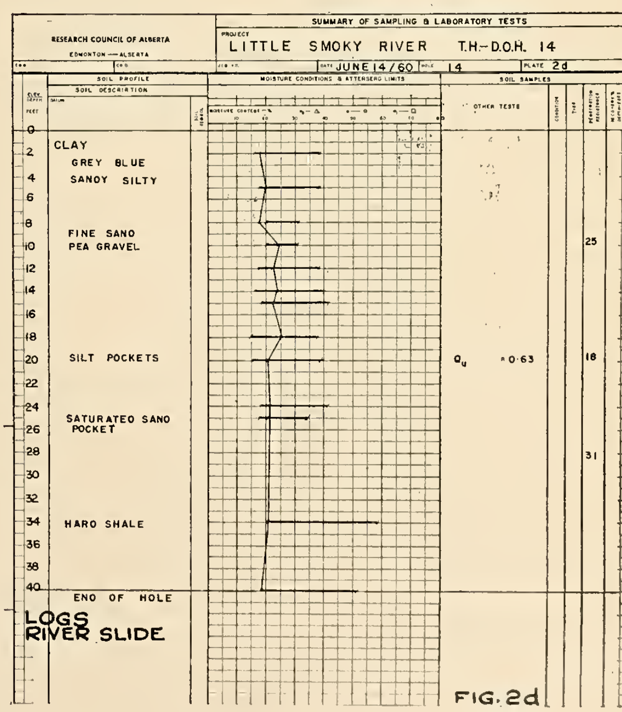
102 Tests

	Min.	*Max.*	*Ave.*
Liquid Limit...	45	80	50
Plastic Limit...	20	30	24
Moisture Content.....	18	30	22
Unconfined Compressive Strength Tons/Sq. Ft.	0.87	11.8	4.5
Standard Penetration Test Results (Blows per foot penetration)........	30	150	60

Following the slide a total of 12 Casagrande type piezometers were installed in and adjacent to the slide area. These were placed at depths varying from 20 to 80 ft. The majority were installed at a depth where the moisture content and limit profiles showed an increase in liquidity index. Six were placed at shallow depths in silty sand in the lower portion of the slide area.

None of those placed in the shale showed measurable pore pressure. In fact, sensitivity tests on the piezometers in the shale indicated a permeability of the soil greatly in excess of that for the intact shale. The loss of water must have been through fissures in the shale. The six piezo-





TEST HOLE LOGS LITTLE SMOKY RIVER SLIDE

FIG. 2c FIG. 2d

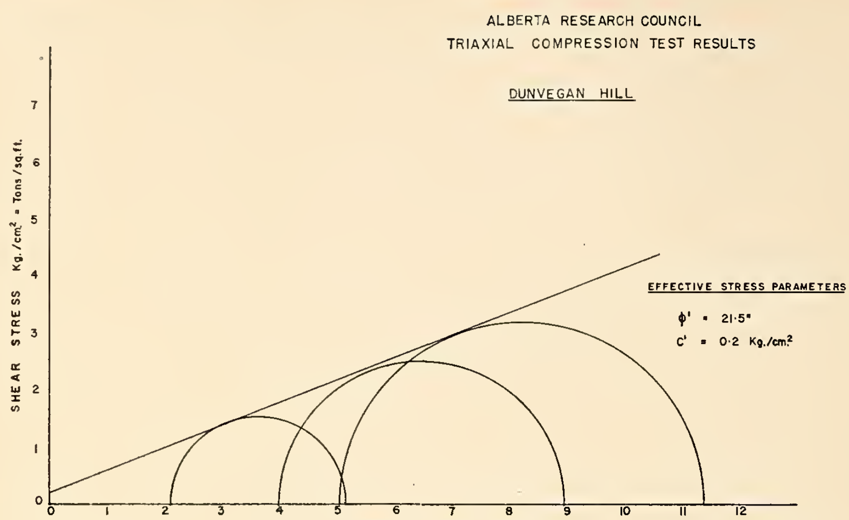


FIG. 3 a

FIG. 3 a

tion program was carried out at the bridge foundation locations and along the highway alignment up the west side of the valley. This bank was recognized as being an old slide area, and several springs and areas of surface ponding of water, including some created by beaver dams, were noted. However, it was concluded that the bank was safe against a slide, and the only measure taken to improve its stability involved improvements in the surface drainage.

Since the fall of 1958 some 54 test holes have been put down in and adjacent to the unstable area around the pier and abutments. The depths of these ranged from 25 to 100 ft. Penetration resistances were run in the test holes and Shelby tube samples were taken for laboratory natural moisture content and limit determinations. Unconfined compression tests were also run on a number of these samples. In the fall of 1960 seven test holes were drilled along the line A-A′ shown in Fig. 8 extending from the river to the top of the west valley bank. Shelby tube samples were taken at 5 ft. intervals in these test holes, and moisture content samples were taken at 2 ft. intervals.

The test holes adjacent to the pier showed drainable subsoil water existed, and during the summer and fall of 1959 an extensive system of horizontal and vertical drains were installed for the purpose of stabilizing the area. The vertical drainage wells were cased so that, if necessary, they could be pumped.

The losg with laboratory test results for one of the test holes adjacent to the pier and one about midway up the bank are shown on Figs. 2c and 2d.

The test holes showed stratified de-

meters in the silty sand in the lower portion of the slide area showed some artesian pressure, but the magnitudes were not sufficient to appreciably affect the stability of the slide area.

A number of the pre-slide test holes were cased with either 2 in. galvanized pipe or alternatively ¾ in plastic tubing. Observations were made for movements in these by probing commencing on May 1, 1959, and continuing until the day before the final rapid movement on May 19. Several of these gave positive indications of the depth of the shear surface developing in the slide area.

Little Smoky River Slide

The second location at which detailed investigations were undertaken is at a river crossing on Alberta main highway No. 34 about mid-way between the towns of Valleyview and Falher in the Peace River area of Alberta. The topography in the river valley is very similar to that at the Dunvegan slide. A cross-section through the unstable area is shown on Fig. 5 and a plan and elevation of the bridge structure is shown on Fig. 7. The valley is about 300 ft. deep, and it will be noted on Fig. 5 that the average slope of the bank is about 7°, and in the area of the bridge about 12°.

The bridge was constructed during the fall of 1956 and the spring of 1957. The bridge was planned with one abutment and one main bridge pier on the west bank. However, wet subsoil conditions were encountered in the construction of the main bridge pier, and therefore the bridge was lengthened by an additional short span and abutment as shown in Fig. 7 to avoid overloading the bank above the pier. The pier was carried on timber piles 21 ft. long driven to a nominal 20 ton bearing capacity. They were, in fact, driven to refusal on comparatively hard clay shale. The two abutments were carried on steel H piles about 40 ft. long. These penetrated into the comparatively hard clay shale for a distance of about 20 ft.

Early in 1958 movements towards the river were observed in the pier. These were recorded as 24 in. towards the river and 2 in. in the upstream direction. The supporting timber piles were also found to be damaged and tipped out of plumb. However, no movement was observed in the two abutments. During the summer of 1958 the pier was underpinned with steel H piles and extended to that the movements of the pier could be accommodated by adjusting the bridge bearings on the top of the pier. Additional movements of 2 to 3 in. have been recorded in the pier since the summer of 1958.

Previous to the construction of the bridge a routine subsurface explora-

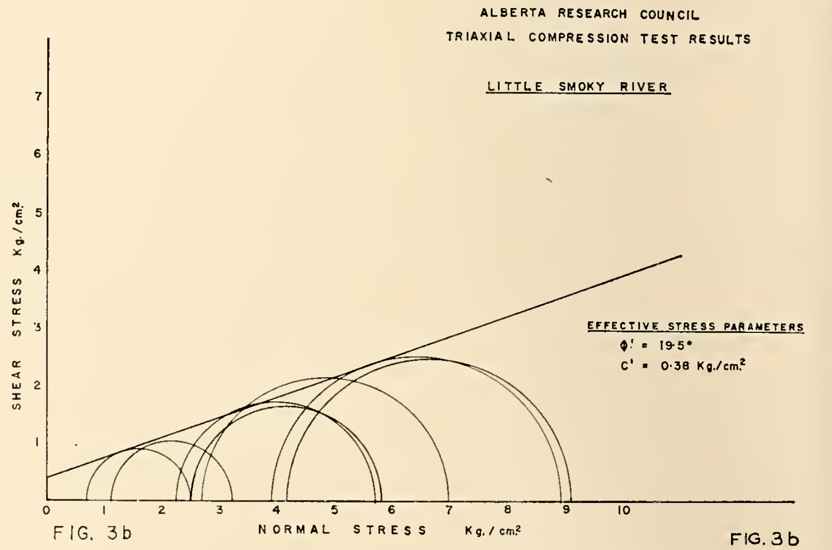


FIG. 3 b

FIG. 3 b

posits of predominantly inorganic clay of medium to high plasticity to depths of from 40 to 80 ft. The clay is interbedded with seams of silt and sand varying in thickness from thin partings to layers several feet thick. The deposits have all been over-consolidated. The clay deposits are underlaid by interbedded deposits of dense sand, sandstone, shale and some gravel.

The test holes located in the lower portion of the bank adjacent to the unstable area around the pier generally showed a wet sand layer at a depth of 20 to 25 ft. below the surface. Above the sand the natural moisture contents of the clay were somewhat higher and the unconfined compressive strengths were lower than at depths below the wet sand. However, in general the liquidity indices are all comparatively low. The laboratory test results along with the pile driving records and performance of the piling below the pier and abutments on the west bank, particularly for the pier, indicated that the unstable area around the pier extended to a depth of 20 to 25 ft. below the surface.

The soil profiles and laboratory test results for the seven test holes on the line A-A8 in Fig 8 are in general similar to what was found for the many test holes in the area of the pier. Free water was found in sand layers in five of these seven test holes. Casagrande type piezometers were installed in these five test holes at the levels of the wet sand. The maximum piezometer levels recorded in these are tabulated in Table 2.

TABLE II.

Test Hole	*Depth of Point Below Ground Surface*	*Maximum Piezometric Level (Depth from Ground Surface)*
ARC 1.....	28 ft.- 6 in.	21 ft. below
ARC 1B...	20 ft.-11 in.	15 ft. below
ARC 2.....	20 ft.- 0 in.	12 ft. below
ARC 3.....	49 ft.-10 in.	2.5 ft. above
ARC 6.....	61 ft.- 5 in.	30 ft. below

Nine consolidation tests were run on samples from test holes ARC 2, 3 and 4. In addition, seven consolidated undrained triaxial compression tests with pore pressure measurements were run on samples of over-consolidated clay from test hole ARC 3. The results of the consolidation tests are shown in Fig. 4b, and of the triaxial compression tests in Fig. 3b. The range of laboratory natural moisture contents, limit values and unconfirmed compressive strengths for the samples from the upper 25 feet of the test holes in the lower portion of the bank are shown in Table 3.

TABLE III.

	No. of Tests	*Min.*	*Max.*	*Ave.*
Liquid Limit..	493	15	70	42
Plastic Limit..	493	10	32	18
Moisture Content....	493	10	31	24
Unconfined Compressive Strength Tons/Sq. Ft.	122	0.25	13.27	2.98

Analysis of Data

Cross-sections through the centre of the two slides are shown in Fig. 5. For the Dunvegan slide the average slope from the toe at the creek to the crown of the slide at the highway grade is about 9°. The location at the top of the slide escarpment and the initial and final toes of the slide are known, and the probings in test holes 2, 6, 14 and 8 gave indications of the depth of the shear surface. These data plus an interpretation of the test hole logs on the cross-section permitted the shape of the shear surface to be defined as being along the line shown on the cross-section in Fig. 5. It will be noted that the slide occurred to a comparatively shallow depth, and that the ratio of length of slide to depth is about 20.

For the little Smoky slide the slope of the ground surface in the area of

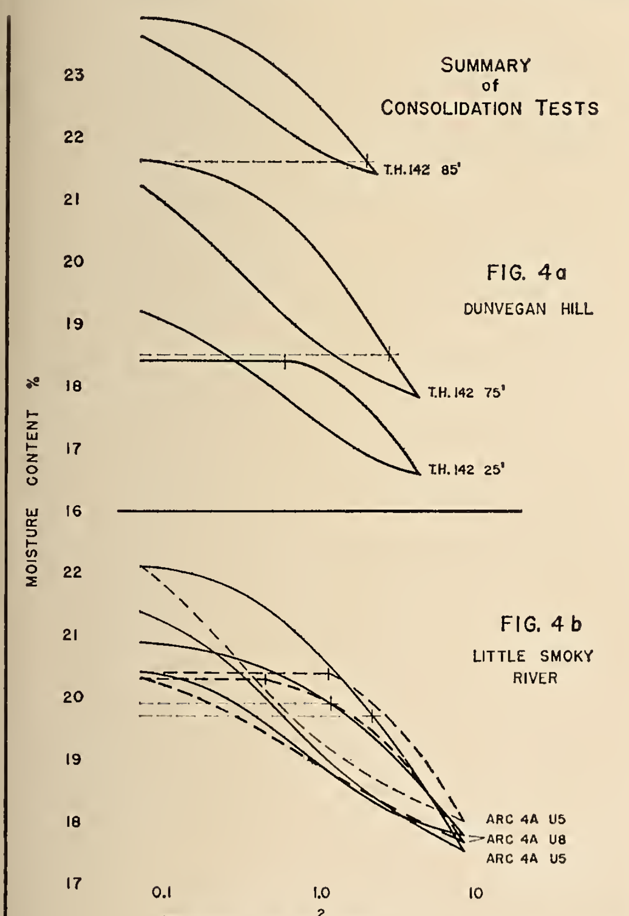


FIG. 4a & b

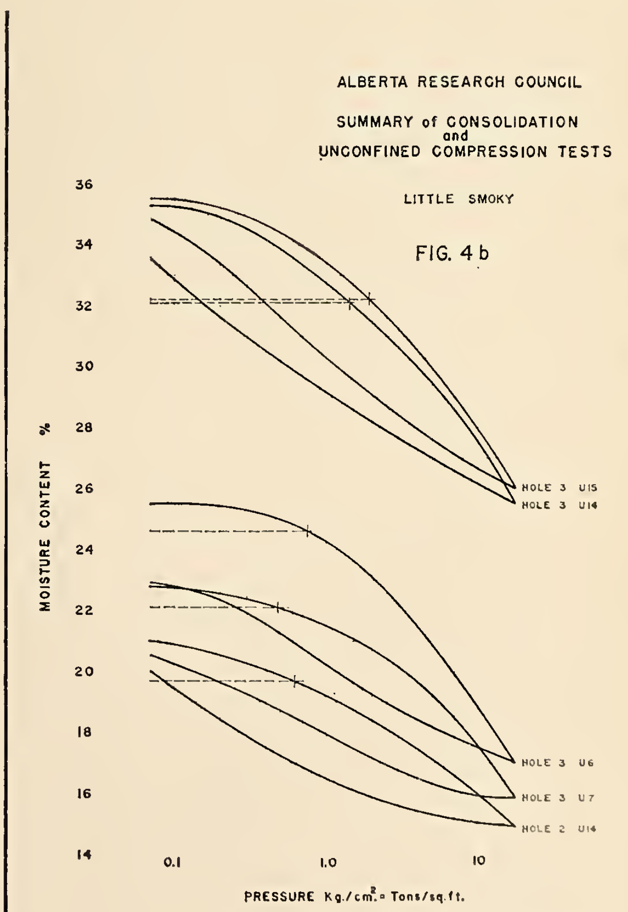
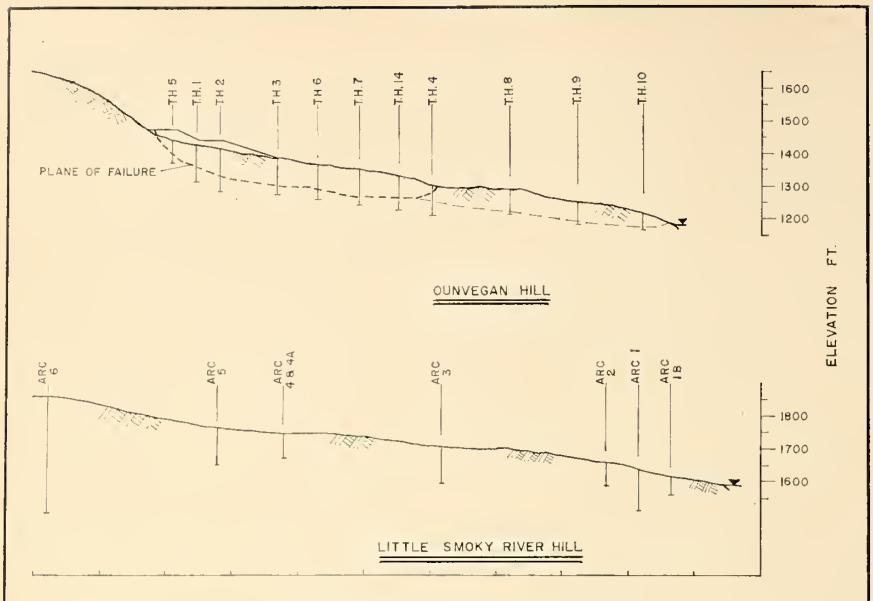


FIG. 4b



CROSS SECTIONS OF SLIDE AREAS
Scale 1"=200'
FIG. 5

the bridge abutments is about 12°. A depth to shear surface was selected at 25 ft. because of the fact that the test hole logs indicated a change to distinctly harder soil at about this depth.

With the shear surface defined it is possible to make a reasonably accurate computation of the average shearing stresses existing on the shear surface at the time of failure. The conventional method of slices or alternatively the infinite slope analysis are applicable to the stability problem.

For the Dunvegan slide the method of slices has been used. The best fit arc through shear surface to the location of the toe in the initial movement has a radius of about 3,000 ft. Using this arc and the method of slices gives an average shearing stress of 1,750 p.s.f. on the shear surface. The infinite slope analysis using the average depth to the shear surface over the whole length of the slide down to the toe at the creek gives an average shearing stress of 1,290 lbs. p.s.f. The value of 1,750 p.s.f. is probably the more accurate, since observations at the time of the failure indicated a certain amount of progressive failure to the extent that the lower portion of the slide developed after the formation of the upper toe.

At the time of the initial failure the factor of safety for the maximum shearing stresses in the slope, of course, was unity. However, if the computed average shearing stress is compared with the average shearing strength from the unconfined compressive strength tests shown in Table I, a factor of safety of 2.6 is indicated. Of the 102 unconfined compressive strength tests only five gave values sufficiently low to indicate a factor of safety of unity for the slide, and these low strengths appeared to be the result of fissuring in the samples. It is, therefore, obvious that the method of analysis using undrained unconfined compression strength laboratory test data as indicating the shearing strength of the soil at failure gives unrealistic results.

While this procedure has proven to be satisfactory in analyzing the stability of slopes in normally consolidated saturated clay soils, it has been recognized for some years that it is not reliable for highly over-consolidated clays, and it has been suggested that stability analyses in terms of effective stresses give more accurate results.[5] The concept of effective stress in soil states that the shearing strength of the soil can be expressed by the equation

$$S = C' + (p - u)\tan\phi' \quad (1)$$

where

S = shearing strength under effective normal stress.
C' = apparent cohesion in terms of effective stresses.
u = pore pressure in water phase of the soil.
ϕ' = angle of internal friction under effective stresses.
p = total normal stress acting on the plane for which the shearing strength is S.

The effective normal stress is the stress difference $(p - u)$ and will be denoted by p_e. The shear parameters C' and ϕ' can be determined from laboratory triaxial tests run as "drained" tests or alternatively as "consolidated undrained" tests with pore pressure measurements. In some practical problems the pore pressure is an independent variable. This is so, for example, in the case of a piezometric pressure above the level of a water bearing stratum. However, in other circumstances, including the conditions in a laboratory triaxial compression test, the pore pressure may be a function of stress ehange. In an attempt to give consideration to the changes in pore pressure which may be a function of stress change, Skempton[10] has suggested that the change in pore pressure, in eq. (1), can be expressed as

$$u = B\,[\Delta\tau_3 + A(\Delta\tau_1 - \Delta\tau_3)] \quad (2)$$

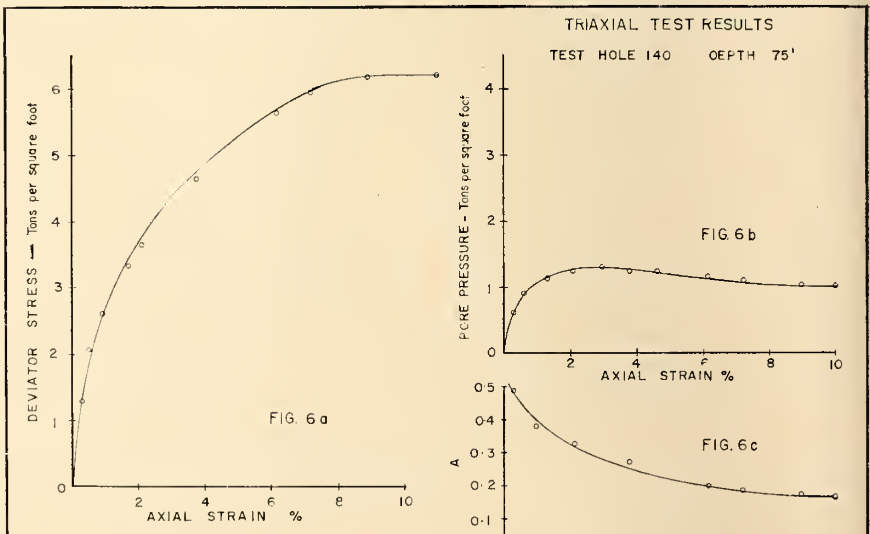
where

$\Delta\tau_1$ = change in major principal total stress.
$\Delta\tau_3$ = change in minor principal total stress.

and

A and B are pore pressure parameters.

The parameter B is closely equal to unity for saturated soils, and A varies over the range of approxi-



DUNVEGAN HILL
FIG. 6 a b & c

nately $+1$ to -0.5 depending upon the stress history of the soil and the proportion of the failure stress applied. Values of A become negative for highly over-consolidated soils.

Fig. 3a shows the results of a set of consolidated undrained triaxial compression tests with pore pressure measurements on a typical sample from the Dunvegan slide area. The sample was from a depth of 75 ft., its natural moisture content was 30%, and its liquid and plastic limits were 80% and 29% respectively. Effective stresses were used in plotting the Mohr failure circles shown in Fig. 3a. A plot of the deviator stress against per cent deformation for one of these tests is shown in Fig. 6a, and a plot of pore pressure against per cent deformation for this same test is shown in Fig. 6b. In Fig. 6c a plot of pore pressure parameter A against per cent axial deformation is shown. It is significant that the pore pressures recorded were all positive, and this same result was secured in all such tests run. The results of a set of seven consolidated undrained triaxial compression tests with pore pressure measurements on samples from the Little Smoky slide are also shown on Fig. 3b. Again, these all showed positive pore pressures.

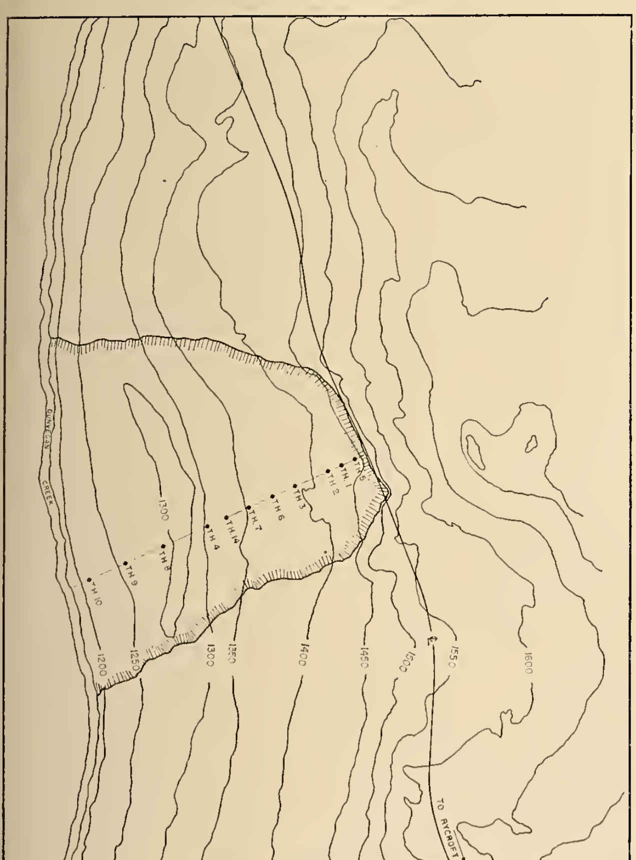
The effective stress concept as expressed in eq. (1) has been applied to each of the two slide conditions using the infinite slope theory with the average depth and slope of the shear surface as shown in Fig. 5. The effective stress shear parameters used are those shown on Fig. 3. Three possible variations have been considered. The assumptions for and the results from these are as follows:

(a) The effective stress parameters C' and ϕ' are considered fully moblized, and the pore pressure is assumed zero. For the Dunvegan slide the indicated factor of safety is then 2.81, and for the Little Smoky slide is 2.95.

(b) The effective stress parameters C' and ϕ' are considered fully mobilized and the value of the pore pressure, u, is computed to give a factor of safety of unity. For the Dunvegan slide, this requires a pore pressure equal to a piezometric level 96 ft. above the slide surface, or 29 ft. above the ground surface; and for the Little Smoky slide a pore pressure equal to a piezometric level 54.5 ft. above the slide surface, or 29.5 ft. above the ground surface is required.

(c) It has been suggested[4, 9] that for highly over-consolidated soils, the cohesion parameter, C', cannot be depended upon for several reasons. If the cohesion parameter, C', is taken as zero, then for the assumption made in case (a) above that the pore pressure is zero, the factor of safety becomes 2.50 for the Dunvegan slide, and 1.72 for the Little Smoky slide. With the assumption that C' is zero, the required pore pressure to give a factor of safety of unity is equal to a piezometric level 78 ft. above the slide surface, or 11 ft. above the ground surface for the Dunvegan slide, and 20 ft. above the slide surface, or 5 ft. below the ground surface for the Little Smoky slide.

It is clear from these analyses that if the pore pressure is assumed as an independent variable very substantial pore pressures are required to account for the instability which developed. A total of 15 piezometers and stand pipes were installed in and adjacent to the Dunvegan slide area, and of these 12 showed measurable piezometric pressures. However, all of them indicated piezometric levels



SITE PLAN
OF
DUNVEGAN HILL

Scale in Feet
200 0 200 400 600 800

Contour interval 50 feet

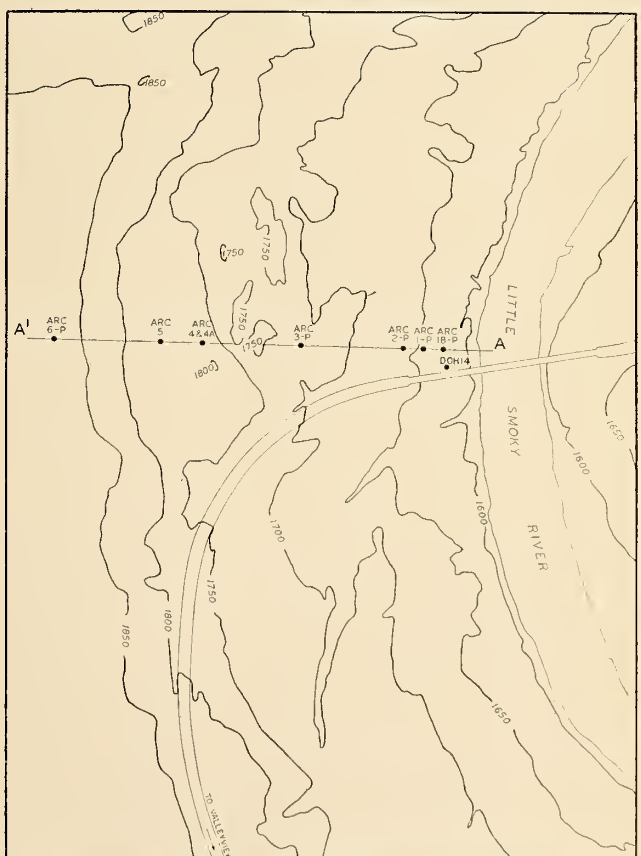


FIG. 8

SITE PLAN
OF
LITTLE SMOKY HILL

Scale in Feet
200 0 200 400 600 800

Contour interval 50 feet

far below that necessary to produce instability with the effective stress analysis. The one which showed the highest pore pressure showed a rise to within 8 ft. of the surface and at the time of the final slide movement it had dropped to 12 ft. below the surface. This pressure was from a sand layer only 25 ft. below the surface. However, even if this piezometric level is assumed as being active on the shear surface, the factor of safety of the Dunvegan slope based on the infinite slope analysis and effective stresses is still 1.77.

The major reason which has been advanced for the fact that stability analyses in over-consolidated soils do not give reliable results of undrained shear strengths are used, is that it has been assumed that over-consolidation produces a dilatant structure in the soil. That is, the soil is so highly compacted that a shearing deformation requires an increase in volume of the soil, and if the soil is saturated negative pore pressures are developed. Such negative pore pressures increase the effective pressure acting between the soil particles as compared to the pressure resulting from the total external loads applied to the soil with no pore pressure existing in the water phase. Under these conditions the pore pressure parameter "A" in eq. (2) becomes negative, the change in pore pressure, u, is less, and the shear strength, s, in eq. (1) becomes greater than if no negative pore pressure existed. Thus, laboratory triaxial compression tests with pore pressure measurements for such a dilatant soil would indicate an effective shearing stress somewhat greater than would be the case if no negative pore pressure existed. However, if it is assumed that under field conditions such negative pore pressures will dissipate with time, then the prototype soil will gradually lose strength as compared to what is indicated in the laboratory test and what may have actually existed in the prototype soil. This hypothesis can explain the reason why a comparison of the average shearing stresses on the shear surface in a slide in over-consolidated soil with the effective strength of the soil from laboratory test may show a factor of safety greater than unity.

If the soil behaviour is to be in accordance with these assumptions, it follows that laboratory undrained triaxial compression tests with pore pressure measurements on the over-consolidated clay shales under consideration, should give negative pore pressures as deformation in the sample develops. However, such tests run on samples from these slide areas, in common with tests on similar types from other slide areas in the same general region, invariably show positive pore pressures as the sample is deformed to failure. It therefore appears that the discrepancy between the behaviour of the soil in the slide as compared to what can be predicted from an effective stress analysis requires some other explanation.

Dilatant Structure

Test results have been reported from several reliable sources which indicate a highly dilatant structure for similar clays much less heavily over-consolidated than the materials encountered at these two locations. It is therefore of interest to inquire into the reasons why shearing tests on these very heavily-consolidated clay shales do not show a highly dilatant structure.

Current concepts of the structure of clay soils[8] postulate plate shaped particles as making up a high percentage of the solid fraction of the soil mass. As the particles settle following deposition in water interparticle bonds may develop between the faces of the plates, at edges and corners of the plates or between the edge or corner of one plate and the face of an adjacent plate. The preponderance of one type of bond as compared to another is influenced by the physico-chemical properties of the soil particles and the aqueous environment in which the particles were deposited.

The development of bonds between edges or between edges or corners and faces of the particles tends to give a very loose card-like structure. The available evidence suggests that deposition in salt water results in the loosest soil structure, and that remolding tends to produce a re-orientation of the particles such that the platy particles lie flat against one another.

Such a loose arrangement of soil particles would be expected to result in a non-dilatant structure. Overburden pressure would be expected to densify the soil mass and if sufficient densification and re-orientation of the particles in the soil mass occurs, a dilatant structure would be produced.

There is no way of estimating what pressure would be required to change a given clay soil from a non-dilatant to a dilatant structure. However, assuming a high percentage of platy particles, high inter-particle bonds and an initial very loose card-like structure, there is no reason, on theoretical grounds, to assume that a dilatant structure would ever be produced by overburden pressure alone. Moreover, it is not difficult on the basis of this hypothesis of the structure of clay soils to understand that a non-dilatant structure might exist during first application of a shearing deformation to an undisturbed soil sample, but that the sample might subsequently display dilatant characteristics as greater shearing deformations are applied. The laboratory test results on samples from two slide areas suggest that these are the conditions which actually developed in the samples, but that sufficient dilatancy did not exist to result in a negative pore pressure before failure of the sample.

Swelling Pressure Hypothesis

If equation (1) is examined from the point of view of possible modifications to the parameters which would result in the available shearing strength as computed from equation (1) being closer to the actual average shearing stress at failure in the slide area, it becomes clear that it is the value of the pore pressure term "u" which is the most unrealistic in comparison to the physical conditions actually known to exist in the side areas. The known physical conditions give a value of "u" considerably too low to meet this requirement. This suggests the possibility that a fourth parameter should be introduced in equation (1) which would be of the same physical nature as the pore pressure term "u".

The clay shales in the areas of these slides generally are capable of exerting significant swelling pressures. The magnitudes of these are dependent upon the existing moisture content of the soil, the over-burden pressure on it and the availability of free moisture, in addition to the mineralogical characteristics of the soil.

If an undisturbed sample is set up in a laboratory consolidation test under a loading equal to the weigth of the overburden under which it existed during its recent natural environment, swelling pressure may be developed if free water is made available to the sample. This usually occurs only with the more highly plastic soil types. If the test is set up with a loading less than the weight of the natural overburden on the sample, swelling pressures invariably develop in the presence of free water. The development of seepage pressure in a layer or zone in such a soil will reduce the effective pressure on the soil and be equivalent to reducing the overburden pressure. Under these conditions swelling or

the development of swelling pressures are to be expected in the soil.

The question arises as to whether the tendency to swell in such a soil will alter the effective stress between the soil particles. It could be argued that the effect of expansion in the soil would be to increase the pressure between the soil particles. A fundamental analysis of what in fact does occur involves one in physico-chemical concepts of the inter-action of clay mineral-water systems, and many of the presently advanced ideas in this field are controversial.[6] However, if one visualizes the interparticle bonds before swelling as being in the nature of tension forces in the water films, then the addition of water may be expected to decrease these tension forces. This would have the effect of decreasing the effective stress between the particles.

Among the current standard tests for determination of the mechanical properties of soils, the consolidation test is the most suitable for measuring the swelling characteristics of a soil. This can be done by holding the volume constant while the sample is given free access to water. The swelling pressure then becomes the load at which reduction in volume commences. Alternatively the sample can be permitted to swell freely under a normal pressure and subsequently consolidated. The swelling pressure can then be taken as the load at which the soil is reduced to the same void ratio as it had before it was given free access to water.

These two tests for swelling pressure do not give identical results, particularly for the more highly swelling soil types. The constant volume test gives lower values of swelling pressure because in this test the sample is consolidated as swelling pressure builds up, and in addition the soil swells against an increasing confining pressure. The constant pressure type of test appears to give more realistic values for the potential swelling pressure which can develop in the soil.

The swelling pressures as recorded from nine consolidation tests on samples from the Little Smoky slide area are shown in Table IV. For the Dunvegan slide area the swelling pressures from four constant pressure type tests gave an average swelling pressure of 1.8 tons per sq. ft.

TABLE IV.

	Constant P test	*Constant e test*
P_s Max...........	2.4	1.2
P_s Min...........	0.48	0.45
P_s Ave...........	1.25	0.82

Equation (1) can be modified as follows to include a term that will reduce the effective stress by the estimated potential swelling pressure of the soil on the slide surface.

$$S = C' + (\tau - u - P_s) \tan \phi' \quad (3)$$

where P_s is the estimated potential swelling pressure of the soil and the remaining symbols are defined as noted above for equation (1).

If the stability of the Dunvegan slide is checked by equation (3) using the average value of 1.8 tons per sq. ft. for P_s, and with the remaining data as used in the stability analysis noted above using equation (1), the factor of safety against movement becomes 0.97. Similarly, for the Little Smoky slide, using a value of P_s of 1.25 the factor of safety against movement becomes 0.98.

Thus the inclusion of a swelling pressure parameter in the basic effective stress analysis appears to give a more realistic assessment of the stability of these two slide areas than results from other conventional stability analyses. Moreover checks against other slides in similar materials in the same general area show that the magnitude of the swelling pressure parameter required to give a factor of safety of unity against movement is well within the range of swelling pressures recorded in constant pressure consolidation tests for the soil types involved.

Practical Implications

Unfortunately the concept of the effect of swelling pressure on the stability of slopes in heavily over-consolidated clay-shales does not point to a simple solution to the stabilization of such slopes. However, it does permit a more accurate assessment of the relative importance of the various factors involved, both in predicting the possibility of a slide in a particular slope, and in stabilizing dangerous areas or those where movement has occurred.

In investigating the stability of such slopes the natural moisture content profile and the existence of seepage zones along with the usual laboratory soil tests are still of prime importance. However, consolidation tests run to indicate potential swelling pressures on representative samples will give information pertinent to the assessment of the real stability of the slope if effective stress stability analyses are used.

In the stabilization of slopes in these materials internal drainage of seepage water and protection of the slope against surface run-off remain of prime importance. However, the concept of the effect of swelling pressure on the stability suggests that the conventional procedure of unloading the top of such slopes may be objectionable and tend to precipitate movement. Toe loading, on the other hand, will generally be advantageous providing it does not block natural drainage from the bank. This procedure was successfully used in the stabilization of the Dunvegan slide by extending a toe across the creek at the lower end of the slope with a culvert to carry the creek flow.

Possibly of greatest significance is that the appreciation of the importance of swelling pressure in the stability of such slopes will direct research to the problem of the possibility of altering the physico-chemical properties of such clay mineral-water systems in situ.

Acknowledgements

The research aspects of the investigation of these two slides were undertaken as part of the co-operative Highway Research Project participated in jointly by the Department of Highways of the Province of Alberta, the Alberta Research Council and the Department of Civil Engineering of the University of Alberta. The Construction Branch of the Department of Highways, of which A. M. Paull is Chief Construction Engineer, were particularly helpful in providing site surveys, subsoil boring information and routine laboratory soil tests.

References

1. Bishop, A. W., and Henkel, D. J., (1957) **The Measurement of Soil Properties in the Triaxial Test.** London, Arnold, 190 p.
2. Bishop, A. W. and Bjerrum, L., (1960), **"The Relevance of the Triaxial Test to the Solution of Stability Problems",** Oslo, Norway, Norwegian Geotechnical Institute publication No. 34, 50 p.
3. Hardy, R. M., (1957), **"Engineering Problems involving Preconsolidated Clay Shales". Transaction of the Engineering Institute of Canada, September 1957.**
4. Henkel, D. J., (1957), **Investigation of two long failures in London clay slopes.** Fourth International Conference on Soil Mechanics and Foundation Engineering. London Proceedings Vol. 2, p. 315-320.
5. Henkel, D. J., Skempton, A. W., (1955), **A landslide at Jackfield, Shropshire in a heavily overconsolidated clay.** Geotechnique, Vol. 5, No. 2, p. 131-137.
6. Low, P. F., (1959), Discussion on: Taylor, A. W.: **Physico-chemical properties of soils.** Ion exchange phenomena A.S.C.E. proceedings Vol. 85, No. SM2, Part 1, p. 79-89.
7. McManus, R. N., Lamb, T., (1960), **"The Dunvegan suspension bridge." Journal of the Engineering Institute of Canada, September 1960.**
8. Rosenquist, I. Th., (1959). **Physico-chemical Properties of Soils; Soil Water systems.** American Society of Civil Engineers, proceedings. Vol. 85, 1959, No. SM2.
9. Skempton, A. W., DeLory, F. A., (1957), **Stability of Natural Slopes in London clay.** Fourth International Conference on Soil Mechanics and Foundation Engineering, London, Proceedings Vol. 2, p. 378-381.
10. Skempton, A. W., (1954), **The Pore Pressure Coefficients A and B.** Geotechnique 4, 143-147.


Imperial research works to keep industry running smoothly
Imperial keeps alert to industry's desire to produce more, while reducing costs. That's why Imperial Oil research works to develop new lubricants and fuels to keep industry running smoothly. Even when a petroleum product has been proven satisfactory, Imperial Research continues to find ways and means of improving that product. For the latest information on lubricants and fuels call the trained Imperial Industrial Sales Representative, at the nearest Imperial Oil Office.
Always
LOOK TO IMPERIAL
for the best
IMPERIAL
Esso
PRODUCTS

COMMENTARY ON CSA STANDARD S16-1961

W. G. Mitchell, M.E.I.C.,
Chairman, CSA Committee S16

D. L. Tarlton, M.E.I.C.,
Development Engineer, Canadian Institute of Steel Construction

CSA STANDARD S16-1961, "Steel Structures for Buildings", is the fifth and latest edition of a specification which had its origin more than 35 years ago.

The first "Specification for Steel Structures for Buildings" published by the Canadian Standards Association appeared in 1924. The number assigned to it was A16, it being the 16th standard to be published. The specification itself consisted of 14 pages, but it also contained several appendices, one of which set forth recommended values for live loads, while another contained the material specification for the type of steel to be used. It is of interest to note that for live loads one must now consult the applicable building code, and that the material specifications for the various structural steels, transferred to a separate publication, now bulk quite large in themselves.

The Canadian Standards Association, originally the Canadian Engineering Standards Association, is a voluntary association of representatives of industry, engineers, architects, and others, devoted to the establishment of standards for the convenience of industry and the protection of the public. The adoption and use of these standards, as such, is purely voluntary. However, in the National Building Code of Canada, and in many municipal building by-laws, we find that appropriate CSA standards have been incorporated, and thus have acquired legal status.

In drafting CSA standards every effort is made to secure representation from all interested parties. Thus the committee to which was entrusted the task of revising the Specification for Steel Structures for Buildings included representatives of structural steel fabricators, the engineering profession, the architectural profession, the academic field, and the Canadian Institute of Steel Construction.

The first edition of the specification now under discussion appeared, as mentioned above, in 1924. A second edition, still numbered A16, was published in 1930. The second edition, like the first, contained an appendix which was the material specification for the type of structural steel in common use at that time. It was what was later termed "mild steel", possessing lower yield and tensile strength than now provided. In 1940, when the third edition appeared, it is found that an important change had occurred, in that the material around which the specification was written, so to speak, was the "medium structural steel" with which we are now so familiar, with its yield point of 33,000 p.s.i. and minimum tensile strength of 60,000 p.s.i. The 1940 specification was renumbered S16, which is the designation by which it is known to-day. Provision was made for the use of the older "mild steel", at unit stresses of 90% of those tabulated for "medium steel".

Fig. 1

Some Typical Specifications for Structural Steel

Numerical Designation	*Title*	*Remarks*
CSA G40.4	Specification for Medium Structural Steel.	Similar in most respects
ASTM A7	Steel for Bridges and Buildings.	
ASTM A373	Structural Steel for Welding.	Mechanical properties almost same as ASTM A7.
CSA G40.8	Structural Steel with Improved Resistance to Brittle Fracture.	Mechanical properties higher than A7 or G40.4. Good notch toughness.
ASTM A36	Structural Steel.	Mechanical properties higher than A7 or G40.4.
ASTM A440	High-Strength Structural Steel.	Intended primarily for riveting and bolting.
ASTM A441	High-Strength Low Alloy Structural Manganese Vanadium Steel.	Intended primarily for welding.

In 1954, the fourth edition of S16 was published. As this edition has been in regular use practically up to the present, little comment is required here. References will be made to certain features of the earlier editions later, to illustrate the manner in which such a specification develops over the years.

It seems appropriate to mention the fact that the detail work on the first four editions of this specification was carried out under the able chairmanship of the late Dr. P. L. Pratley, the eminent Montreal consultant. We may well pay tribute to a lifetime of service to the engineering world.

In 1940, the basic material for steel structures for buildings had become the steel identified with CSA Specification G40.4 or American Society for Testing Materials (ASTM) Specification A7. The permissible axial tension on net section was 20,000 p.s.i. Rivet shear was 15,000 p.s.i. and girder web shear was 13,000 p.s.i. These figures remained in force right through to 1961, nor have they, in reality, been abandoned now. That statement must be qualified, however, with regard to the war years, when there was in use the "National Emergency Specification", which took tensile stress up to 24,000, rivet shear up 17,000 and web shear up to 14,000 p.s.i. After the war, the old standards were reinstated. One may ask, why the higher figures should not be retained, if they could be used with apparent safety during the war. One answer to that is, that there was little or no building during the war apart from the demands of the actual war effort, so that the application of the uprated stress figures were, in effect, restricted to certain types of buildings, constructed under government sponsorship and supervision. Building in times of peace may proceed under quite different conditions.

Whereas the structural steel fabricating industry has been using heretofore, for most of its work, one standard type of steel, we find ourselves to-day in a different situation. (Fig. 1) High-strength steels under various "brand names" have appeared on the market, offering yield strengths in the 50,000 p.s.i. region. Still more recently, there were published the

ASTM standards A440, A441 and A36, and a very interesting Canadian specification which does not have a duplicate elsewhere, CSA G40.8. These developments made it increasingly important to study the S16 specification from the viewpoint of its application to steels other than the familiar G40.4. In the fourth edition, provision was simply made for the use of other steels at stresses directly proportionate to their respective yield strengths. Up to a point, this was quite satisfactory but it was a principle which could not be applied indiscriminately. The design of slender columns is an instance where the determination of strength by consideration of the yield level is not a valid assumption. Some adjustment was also needed in dealing with such items as girder web plates. Other specifications, such as the well-known AASHO specification for highway bridges, had formulated rules in such cases, and Committee S16 had to make a careful survey of the situation.

In the new edition of S16 there will be found permissible unit stress figures based on the same yield strength as specified before, 33,000 p.s.i. In addition, however, values are provided for steels which have a specified minimum yield point other than 33,000 p.s.i. What might be termed the "base stress", the tensile stress on net area, is not to exceed 0.61 times the specified minimum yield strength, although this has been hedged with a precaution to the effect that the "base stress" must not exceed one half of the minimum ultimate strength of the steel. This last may seem rather an unnecessary measure, until one looks more closely into the figures for some of the high-strength steels now available. It will be found that in some cases the margin between the minimum yield point and the minimum ultimate stress is considerably less than what we tend to assume from long familiarity with G40.4 or A7. (Fig. 2)

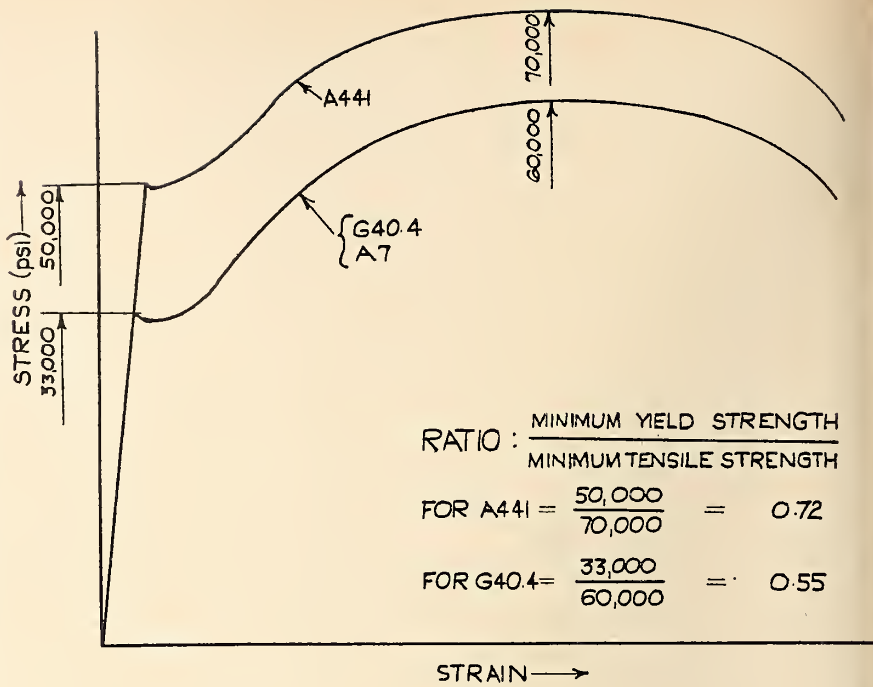


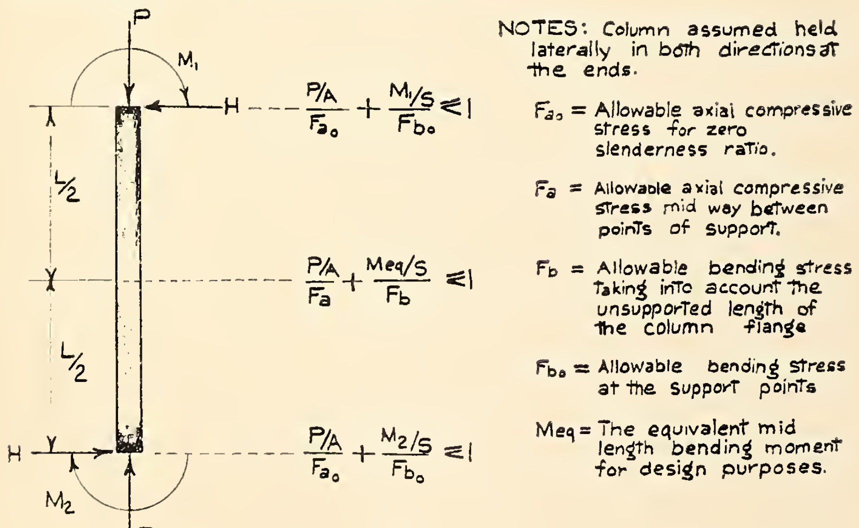
Fig. 2.

One of the problems which confronted the committee was that of identification of structural steels. Designers in this country are familiar with the structural steels which appear in the CSA G40 series, or in the ASTM standards. From time to time, however, the question is brought up of the use of steels produced to other than these standards. The specification endeavours to protect the interests of all concerned by saying that "other steels" must conform to "an approved specification for a steel of structural quality". Here, as elsewhere, "approved" means approved by the authority having jurisdiction or by the representative of the purchaser. In S16, it is quite feasible to list the "standard" types of steel which are always in mind during the writing of the specification; it is hardly practicable to make a ruling on every kind of structural steel, domestic or imported, which may be available. The way of over-caution would be to permit the use of only the well-known steels. However, this would place not only an unjustifiable barrier in the way of possibly sound material, it would hinder the use of any new structural steel which our own steelmakers might develop in the next few years. Generally speaking, it is intended that structural steels conforming to familiar and recognized standards such as CSA or ASTM be considered as conforming to "approved" specifications and that these steels be used as applicable. However, structural steels conforming to less familiar standards also should be acceptable when the quality of the material (as defined by the provisions of the material specifications to which they are produced) is suitable for the intended use and this is agreed upon beforehand by all parties concerned.

The new fifth edition of CSA S16 contains, like its forerunners, a significant preface.

This preface reiterates some fundamental concepts which should be borne in mind. Foremost of these, is the fact that a specification is not intended to function as a text book, and that its contents, which must be as compact as possible, are intended for the guidance of the experienced

Fig. 3. Requirements for columns subject to axial load plus end bending moments—CSA S16-1961



rather than for the instruction of the uninitiated. On the other hand, where there was sometimes the temptation to omit an item on the grounds that "everybody knows that", it was still thought advisable to insert at least a warning sentence or reminder. Experience was sometimes on hand to show that some seemingly obvious item could actually be overlooked.

There may well be requirements in the new edition of S16 which the user might wish were more explicit. When it speaks of "live load being preponderant" in a member, or "eccentricity being excessive" in a connection, just what is meant? How much live load must there be before it is preponderant, and at what point does eccentricity become excessive? It can only be said that the experience of the designer must be the criterion. One might, for instance, add illustrations of various eccentric connections, and give formulae for calculating the stresses therein, but there would be little chance of providing data which would be complete enough to cover all cases which might arise. In the British specification, BS449:1959 several pages are devoted to an exposition of the manner in which the effective slenderness ratio for various types of columns should be selected; and yet, there are column conditions which have not been included. Some of the material related to compressive stresses is covered at greater length in the Belgian specification, NBN 1, for instance, than is the case in either Canadian or U.S. standards; yet, it is possible to ask some questions which are not explicitly answered in that specification. The aim in S16 has been to indicate that a problem exists, but to leave it to the technical competence of the designer to solve it. It does not purport to relieve the designer of his responsibility to prepare an adequate design.

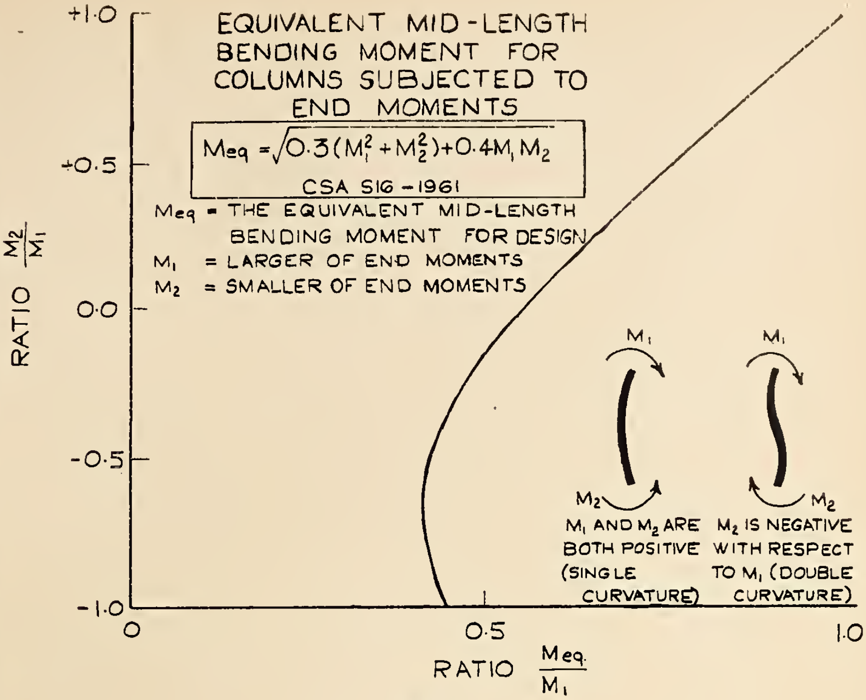


Fig. 4.

A systematic review of the new edition of the specification may be of general interest. The specification consists of 34 sections or chapters, each covering a specific aspect of design, fabrication or erection.

In addition, there are four appendices intended to provide supplementary information.

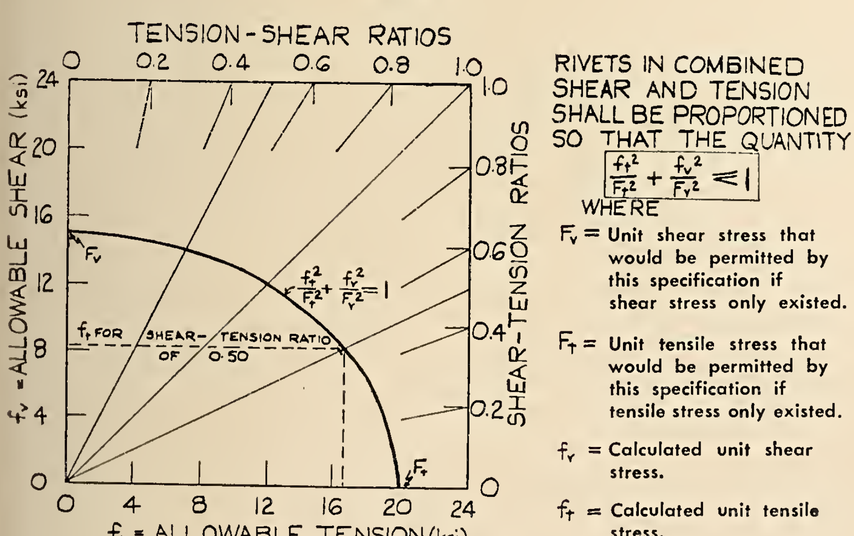
Only the more important portions can be dealt with here, although some seemingly insignificant clauses have been the subject of considerable committee work. For example, in the very first clause, it had to be decided whether it would be possible to include in S16 the data on light-gauge steel construction hitherto excluded. It will be seen that the subject is still excluded from the scope of S16, but due in part to a recommendation of Committee S16, light-gauge steel design now has been committed for study to a separate committee of the Canadian Standards Association.

The section on "Types of Design" has been revised in order to provide a place for Plastic Design, information on which appears later. It is of interest to note that a forecast of this development actually appeared in clause 4.5 of the previous fourth edition.

Although no change has been made in section 6, dealing with plans, it might not be out of place here to call the attention of designers to the requirement that design drawings should contain not only the sizes and locations of members, but such data on loads, shears, moments and axial forces as may be required for the proper preparation of the shop drawings. There have been times when some of this information has remained secreted in the design brief, leaving it to the fabricator to do a certain amount of scientific guesswork. Surely the elimination of guesswork wherever possible is to the benefit of all.

For members subject to both axial and bending stresses, the familiar "interaction formula" is retained. (Fig. 3) To this, however, has been added a formula, believed to have originated with Professor Massonnet, which provides a method of calculating an equivalent bending moment assumed to act at mid-length of a

Fig. 5.



column subjected to end bending moments. (Fig. 4) Other guidance is also given for the treatment of combined stresses in design.

In the case of rivets subject to combined shear and tension, research data which have become available since the publication of the fourth edition have made it possible to give more explicit instructions regarding allowable combined stresses. (Fig. 5)

In the section dealing with composite beams, a change has been made which merits some explanation. A sentence reads, "The entire composite cross-section may be assumed as effective in computing total stresses due to all dead and live loads." This represents a departure from previous thinking, according to which the full strength of the steel beam could not be assumed if it had already been stressed by the weight of the concrete prior to hardening of the concrete. At a seminar held in Toronto late in 1959, it was pointed out that for a given combination of steel beam and concrete slab, the ultimate strength was found to be the same, whether the beam had or had not been shored during the placing of the concrete, although there was a slight difference in the stress under working load. Of course, it is still necessary to ensure that the steel beam is adequate to carry the weight of the concrete, if unshored, and to check the deflection which will result from the procedure adopted.

The clause on "Effective Span Length" is short, and has not suffered a major revision. Nevertheless, the discussion of this clause in committee brought forth some interesting points, and it is also instructive to read it in the light of certain provisions found in the editions of 1924 and 1930. The earlier specifications stated that the equivalent length of a beam, for the calculation of bending moments, might be taken as the distance between gauge lines in the web connection angles, when standard connection angles were used. The early editions also made some provision for reducing the effective length of a plate girder, when the latter was connected by a full-depth connection to a rigid support. Later, we find this changed to the present type of clause, which states that the span length for design purposes shall "generally" be taken as the distance between centres of supporting members.

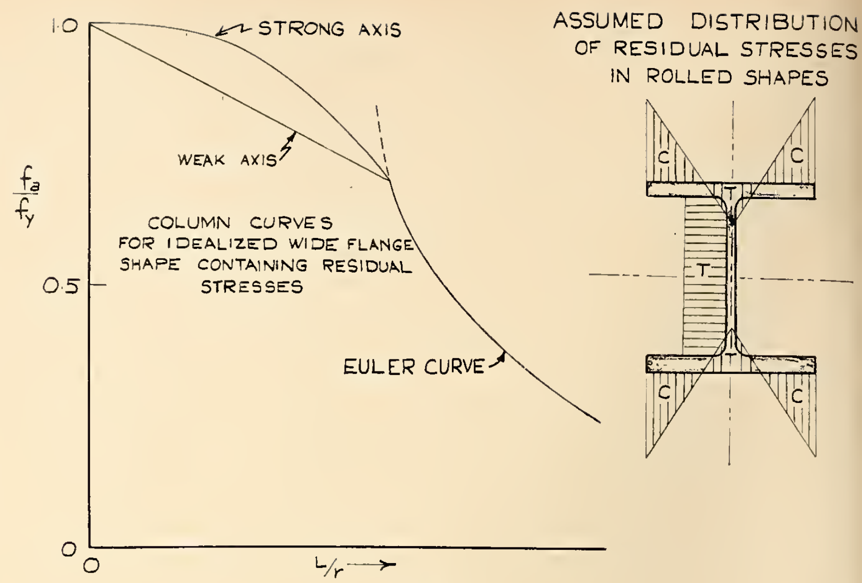


Fig. 6.

Taking the effective length of a beam as the distance between centres of supports is on the safe side as far as the design of the beam is concerned, and it also has the merit of simplicity. Also, as far as the beam design is concerned, there should be little hesitancy about calculating or recalculating bending moments on the basis of actual clear span when this can be accurately ascertained. Let it be clear, however, that no matter what assumption is made regarding the effective span of flexural members, the effect of eccentricity of loading must be taken into account in the design of the supporting member. The specification does not countenance under-design of a supporting column because of over-design of the beams which are supported by it.

This brings us to the all-important matter of unit stresses. Reference has already been made to the relationship between the guaranteed minimum yield point of a steel, and the permissible tensile stress. The practice adopted generally with regard to unit stresses has been to maintain the same ratio between them and the yield point as already exists for CSA G40.4 or ASTM A7 steels. Exceptions to this practice have to occur, however, in the formulae which deal with the possibility of buckling. It has long been accepted that the failure of slender compression members, and the behaviour of some compression flanges and thin webs, is governed by the modulus of elasticity rather than by the yield strength or ultimate strength of the material. Precautions must therefore be taken against allowing steels to be rated in direct proportion to their respective yield strengths if there is a possibility of such failure within the elastic range of buckling.

By a fortunate coincidence, the work of the Column Research Council was approaching publication at the time when Committee S16 had to make a decision on the type of formula to be used for allowable stresses in columns and other compression members. In the book recently published by the Council, the title of which is, "Guide to Design Criteria for Metal Compression Members", there is to be found a very useful summary of the work, both theoretical and experimental, (complete with numerous references) which has been done on this ever-present problem. It should be noted, however, that the Column Research Council has not proposed any design compression formulae, preferring to state facts and make suggestions, from which engineers may derive the type of formula which seems best suited for the purpose in hand.

Recent study has brought to light the fact that in the familiar H section used for most building columns, residual stresses are developed, owing to a difference in the rate of cooling of the steel towards the toes of the

Fig. 7

Evolution of Column Formula (CSA Spec'n.)

1924	$F_a = 14{,}000 - 1/3(L/r)^2$ [for "Mild" Steel]
1930	$F_a = 17{,}000 - 60(L/r)$ not to exceed 15,000 [for "Mild" Steel]
1940	$F_a = 20{,}000 - 70(L/r)$ not to exceed 18,000 [for "Medium" Steel]
1948	Same as 1940
1954	$F_a = 20{,}000 - 70(L/r)$ not to exceed 18,000 (multiplied by $(2.0 - L/150r)$ for L/r greater than 150)
1960	$F_a = [20{,}000 - 70(KL/r)](fy/33{,}000)$ but not to exceed $\frac{145{,}000{,}000}{(KL/r)^2}$

flanges and the middle of the web, as compared with the areas where web and flanges meet. Photographs actually show that the latter zones are still red-hot when the less-protected parts of the section are dark. The residual stresses so developed are by no means negligible. (Fig. 6) It would appear that any formulae, however elaborate, which do not take into account the existence of such a condition may be difficult to justify. It appears advisable, therefore, to adopt the simplest formula which will conform with reasonable accuracy to the observed behaviour of column sections under actual test.

A comparison of the column formulae which have been incorporated in this particular specification, in successive editions, may be of interest. (Fig. 7) In 1924 we find the formula

$14{,}000 - 1/3(L/r)^2$ this being for steel with a yield point around 27,500 p.s.i. In 1930, we find that a straight-line formula has been adopted, thus:

$17{,}000 - 60(L/r)$ not to exceed 15,000. In 1940, for steel with the same yield point as our present G40.4 or A7, the straight-line formula became:

$20{,}000 - 70(L/r)$ not to exceed 18,000. This last expression will be familiar to many, since it was adopted without change in 1948 and again in 1954.

The limiting range through which any column formula may be applied is important. (Fig. 8) In 1924 the upper value for L/r was set at 130, except for cases where special permission was obtained. In 1930, the limits set were 130 for columns and 175 for other compression members. In 1940 the slenderness ratio for columns was generally not to exceed 150, with a limit of 200 for other compression members. In 1954 the limits are similar, with this difference, that for values of L/r greater than 150, a modifying factor was introduced which had the effect of deflecting the original straight line beyond that limit into a flat curve with a steeper inclination.

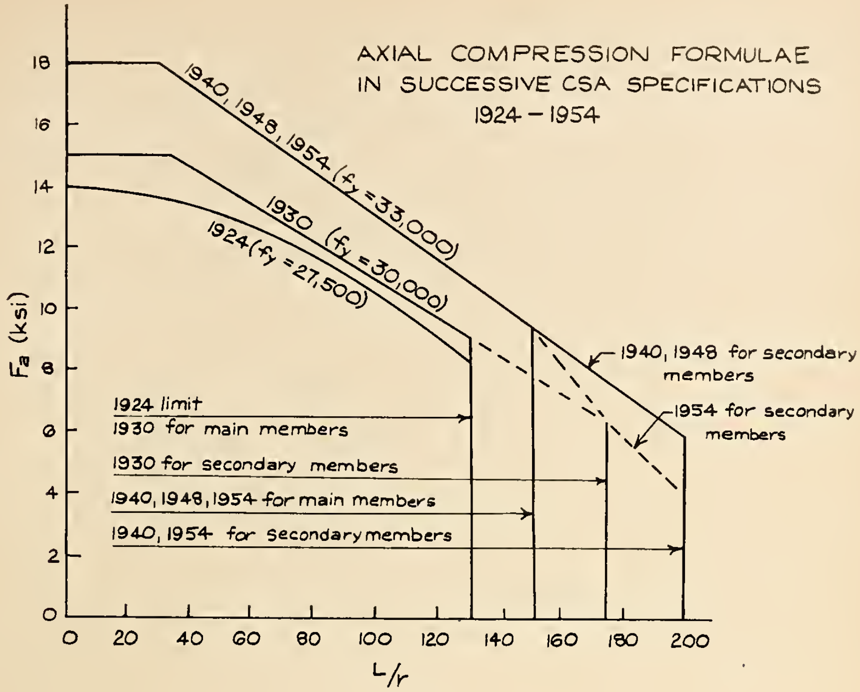
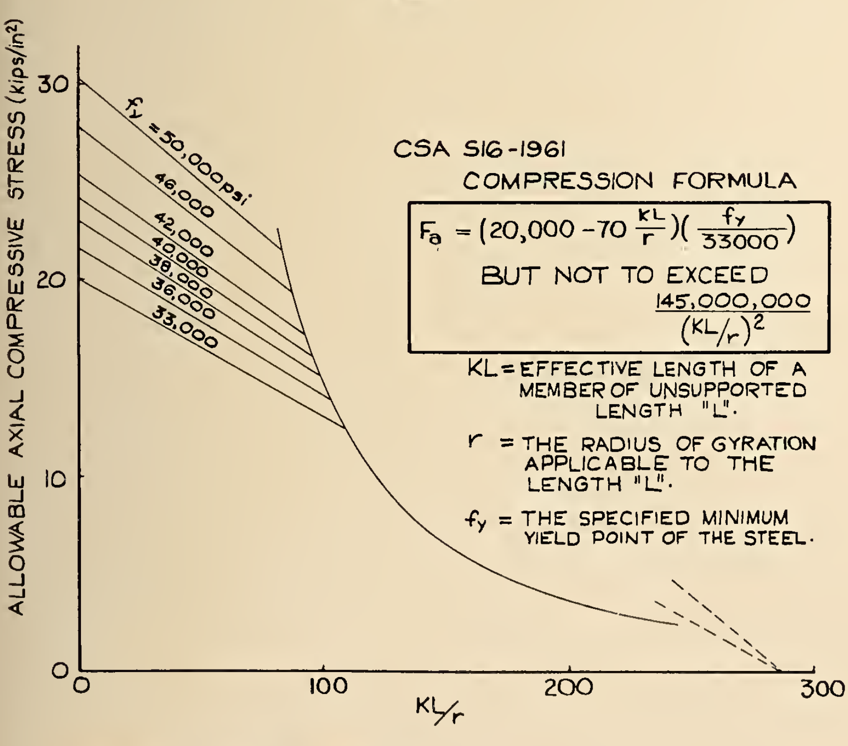


Fig. 8.

Comparison of the compression formulae adopted by various technical bodies in different countries is most readily made by plotting the respective curves. To obtain a true comparison, such curves should be reduced to the basis of the same kind of steel. On this basis, it may be seen that the formula adopted in 1954 rises above most of the others in the range of slenderness ratios between, say, 100 and 200. It may also be noticed that part of the curve approaches rather closely to the Euler buckling curve for L/r equal to about 150. Calculations disclosed the disquieting fact that if allowable column stresses could automatically be increased in proportion to the minimum yield point of a steel, some of the resulting curves would actually intersect the Euler curve. It need hardly be pointed out that the position of the Euler curve, which is dependent on the modulus of elasticity rather than on the yield point or tensile strength of the material, does not change appreciably for any of the structural steels which we use today.

The specification committee spent much time with the problem of the compression formula, and if it were not for the considerations of space and time, an analysis and comparison of the various suggestions which were brought forward by committee members could be made, and would be

Fig. 9.



found of considerable interest. It was generally agreed that what we may call the right-hand part of the curve should be controlled by the Euler equation, and in fact the outline adopted has ordinates equal to approximately one-half those of the Euler curve. The left-hand portion was to be a straight line, and it was observed that our formula of 1940, 1948 and 1954 had stood the test of time, and did not seem to diverge too widely from other formulae in that range. It was therefore decided to retain the expression

$$20{,}000 - 70(L/r)$$

for the range up to our one-half-Euler curve, with this exception, that the upper limit of 18,000 was discarded, allowing the line to continue unbroken up to the left-hand axis.

The revised compression formula now appears thus: (Fig. 9)

$$(20{,}000 - 70(KL/r))\left(\frac{fy}{33{,}000}\right)$$

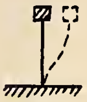
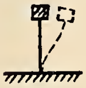
but not to exceed

$$\frac{145{,}000{,}000}{(KL/r)^2}$$

Provision for the application of the formula to high-strength structural steels is made in the right-hand part of the first formula, and a brief examination will show that the line for any particular steel will intersect the left-hand axis at a point proportional to its yield strength. It may also be observed that the first part of the formula vanishes when 70(KL/r) is equal to 20,000; all the straight-line portions, therefore, converge on a common point on the horizontal axis. This renders it a simple matter to draw in the line for a steel with any known value of f_y. The straight line formula now adopted can be correlated to the buckling strength about the weak axis of I-shaped columns having residual compressive stresses

TABLE 2 (Fig. 10)

Minimum Design Values of Effective Length Factor "K" for Compression Members

Degree of End Restraint of Compression Member	*Min. Eff. Lgth. Factor K*	*Symbol*
Effectively held in position and restrained against rotation at both ends.	0.65	
Effectively held in position at both ends, restrained against rotation at one end.	0.80	
Effectively held in position at both ends, but not restrained against rotation.	1.00	
Effectively held in position and restrained against rotation at one end, and at the other restrained against rotation but not held in position.	1.20	
Effectively held in position and restrained against rotation at one end, and at the other partially restrained against rotation but not held in position.	1.50	
Effectively held in position at one end but not restrained against rotation, and at the other end restrained against rotation but not held in position.	2.00	
Effectively held in position and restrained against rotation at one end but not held in position nor restrained against rotation at the other end.	2.00	

in the toes of the flanges. As mentioned previously, the formula

$$\frac{145{,}000{,}000}{(KL/r)^2}$$

can be correlated to the buckling strength of slender columns wherein the effect of residual stress is considerably diminished by virtue of the fact that such columns buckle elastically before the induced stresses reach the yield level at any point of the cross-section.

It is realized that no compression formula can be regarded as perfect. That now presented may be criticized, perhaps, because the line which dictates the permissible stress for a given grade of steel breaks more or less sharply at the point where the straight-line portion intersects the curved portion. It is to be remembered that we are trying to approximate experimental results, rather than interpret a purely mathematical analysis, and in this connection it may be mentioned that the work of the Column Research Council includes a curve with a similar break, applicable to buckling of an H-section about the weak axis. It should also be pointed out that a break at this point is hardly more illogical than the break which was displayed by the previous S16 column curve at the upper limit of 18,000 p.s.i.

It will be seen that in place of the old slenderness ratio of L/r, there now appears the ratio KL/r. The factor K is explained in that section of the specification which deals with Slenderness. (Fig. 10) It is used to make some provision for the effect of end conditions in a compression member. If the ends of such a member are not effectively restrained against rotation, K must be taken as not less than unity. A conservative value must be used where conditions of end restraint cannot adequately be ascertained. The lowest value permitted for K is 0.65 for a column with both ends fully restrained, while a cantilever member may have to be designed with a value of K as high as 2.00. For purposes of analysis there is an appendix in which the method developed by Jackson and Moreland, and published by the Column Research Council, is set forth.

Fig. 11

Evolution of Compression Flange Formula in CSA Specifications

1924:	$16{,}000 - 150L/b$	For "Mild" Steel $fy = 27{,}500$
1930:	$18{,}000 - 170L/b$	For "Mild" Steel $fy = 30{,}000$
1940:	$25{,}000 - 333L/b$	For "Medium" Steel $fy = 33{,}000$
1954:	For Rolled Beams;	$\frac{12 \times 10^6}{Ld/bt}$ not to exceed 20,000
	For Built-up sections;	$25{,}000 - 333L/b$ not to exceed 20,000
1961:	For symmetrical I-shaped sections;	$\frac{12 \times 10^6}{Ld/bt}$ or $\frac{12 \times 10^6}{(L/b)^2}$ whichever is greater but not to exceed $0.61fy$

A problem somewhat similar to that of the compression member, but perhaps even more complex, is that of the compression flange of a beam or girder without lateral support. It is a problem which has been analyzed by experts and subjected to laboratory tests, without being reduced to any simple general solution. Various expedients have been adopted, from time to time. (Fig. 11) Perhaps we may glance briefly at earlier editions of the specification in this connection. In 1924 the simple straight-line formula was used:

16,000 —150(L/b), this being for "Mild steel";

In the 1930 edition this was modified to:

18,000 —170(L/b),

In 1940, for the "medium steel" still in use to-day, we find:

25,000 —333(L/b), not to exceed 20,000. In 1954, the well-known formula

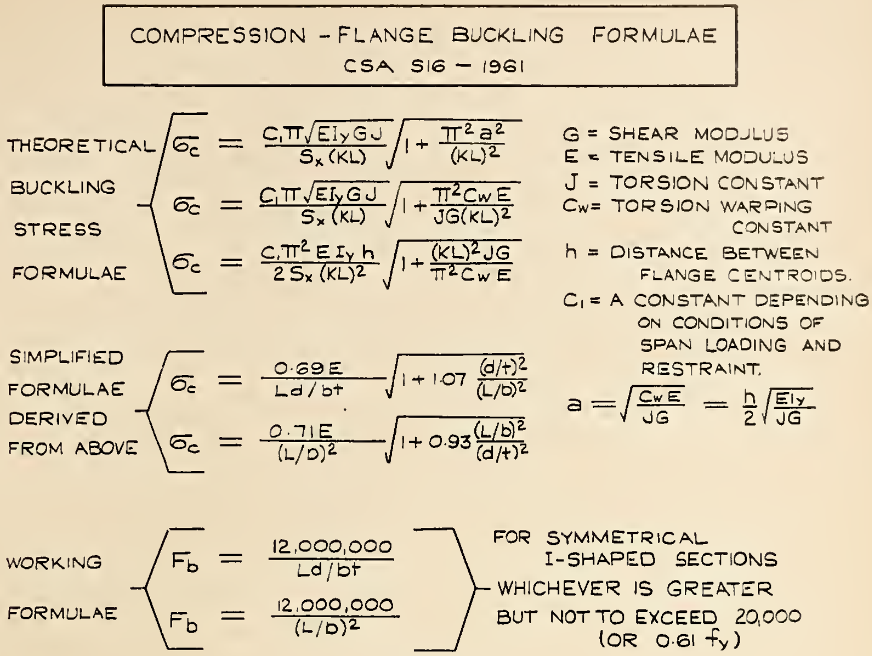


Fig. 12.

$$\frac{12{,}000{,}000}{(Ld/bt)} \text{ not to exceed } 20{,}000$$

was adopted for rolled sections only, while the earlier formula

25,000 —333(L/b)

was retained for plate girders and built-up sections. The inclusion of the second formula was in recognition of the fact that the first is only valid for I-shaped sections of which the geometrical proportions lie within certain limits. However, the two formulae do not work well side-by-side, and in the latest revision it was though advisable to drop the old straight-line formula altogether. There still remained the question of the general applicability of the other formula, and of the possibility of finding alternatives to it.

For those who are specially interested in the problem of the laterally unsupported beam, the book published by the Column Research Council provides a very interesting review of the subject, backed by numerous references to the pertinent literature. Even for doubly-symmetrical sections of I or Wide-Flange shape, subject to simplified forms of loading, the equations which are developed for the critical stress are far from the type of formula suitable for inclusion in a specification. One equation appears in three forms, thus: (Fig. 12)

$$\sigma_c = \frac{C_1\pi\sqrt{EI_yGJ}}{S_x(KL)}\sqrt{1+\frac{\pi^2a^2}{(KL)^2}}$$

$$\sigma_c = \frac{C_1\pi\sqrt{EI_yGJ}}{S_x(KL)}\sqrt{1+\frac{\pi^2C_wE}{JG(KL)^2}}$$

$$\sigma_c = \frac{C_1\pi^2EI_yh}{2S_x(KL)^2}\sqrt{1+\frac{(KL)^2JG}{\pi^2C_wE}}$$

σ_c = critical stress
E = tension modulus
G = shear modulus
h = distance between flange centroids
J = torsion constant
C_w = torsion warping constant
C_1 = constant depending on conditions of loading and restraint

$$a = \sqrt{\frac{C_wE}{JG}} = \frac{h}{2}\sqrt{\frac{EI_y}{JG}}$$

S_x = section modulus about bending axis
KL = effective span length

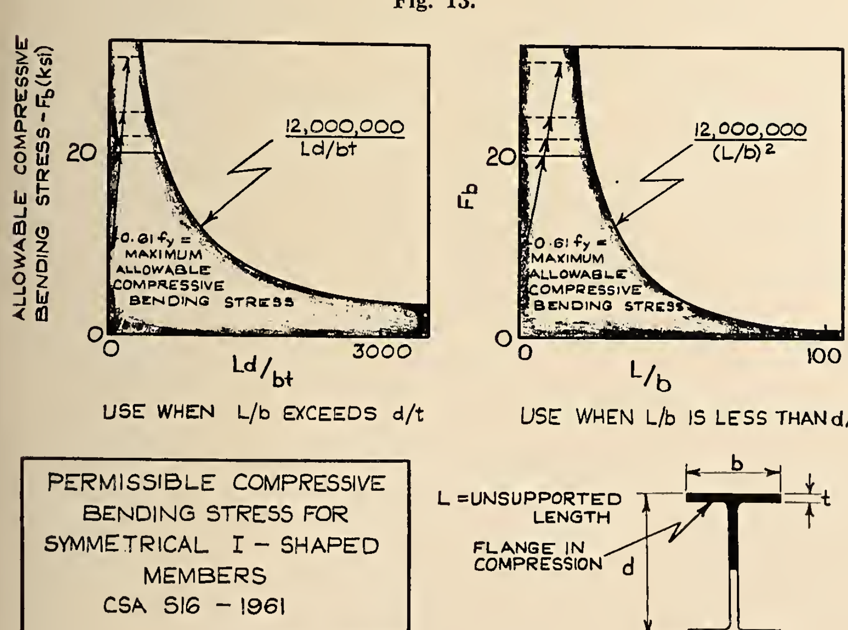
As we are not able, here, to examine the make-up of these formulae in detail, still less the extensive literature on the subject, it shall have to be sufficient to say that from the first of the equations above, certain simplifying assumptions regarding the properties of the section enable the following equation to be written:

$$\sigma_c = \frac{0.69E}{Ld/bt}\sqrt{1+1.07\frac{(d/t)^2}{(L/b)^2}}$$

b = flange width
d = depth of beam
t = flange thickness
L = laterally unsupported span

while from the third equation the

Fig. 13.



following is derived:

$$\sigma_c = \frac{0.71E}{(L/b)^2}\sqrt{1 + 0.93\frac{(L/b)^2}{(d/t)^2}}$$

It is worth noting, at this point, that the latter equations apply to the simple beam with no bending or warping restraint at the ends and with loads applied by end couples that cause uniform elastic bending throughout. This is, admittedly, only a rough approximation to the condition of the usual type of building member. The two equations just given have been further simplified to obtain two "working" formulae, given below: (Fig. 13)

$$F_b = \frac{12{,}000{,}000}{Ld/bt} \quad \text{or} \quad \frac{12{,}000{,}000}{(L/b)^2}$$

(whichever is greatest) but

not to exceed 0.61 f_y.

These formulae are given as alternatives in the revised specification. In the majority of cases, the first will govern, but in the case of a beam or girder in which L/b is less than d/t, the second may be applied.

Of the formulae now given in the specification, it may be said that they provide the most effective means found, up to the present, of dealing with the most commonly used type of section in building work, the I-shaped section. Much thought was given to the possibility of providing data applicable to unsymmetrical sections, or to box-shaped sections. It was reluctantly decided that it would not be practical to condense into suitable form such design information as may now be available. It is to other sources, such as the Column Research Council "Guide", that we must refer the structural designer who finds it necessary to use a type of section not covered by the revised edition of S16.

There have been other changes in unit stresses, besides those relating to compression members and compression flanges. In March, 1960, a new specification for "Structural Joints Using A325 Bolts" was published with the approval of the Research Council on Riveted and Bolted Structural Joints. As copies of this specification, and of the commentary published with it, have been circulated by the bolt manufacturers and others, it is not necessary to dwell on it at great length. The design of high strength bolted joints which now forms the closing section of S16 embodies the new data. Similarly, where such bolts are mentioned in the section on unit stresses, the new values are given. It may briefly be stated, that if high-strength bolts are used in a "friction-type" shear connection, the bolt value remains the same as a rivet of the same size; but if the connection is what is called the "bearing type", in which a very small one-time movement of the connected parts is not objectionable, the shear stress in the bolt may be increased to 22,000 p.s.i. on the unthreaded shank. This is a rather important advance, leading to economy in the size of connections. It may also be pointed out that a tensile value for high-strength bolts is now given, which, being based on the actual proof strength of the bolt is for convenience referred to the nominal rather than the net area of the bolt.

The formula for shear stress in the webs of beams and girders now appears in the form: (Fig. 14)

$$\frac{64{,}000{,}000}{(h/t)^2}, \text{ not to exceed } 0.40fy,$$

for unstiffened webs. No limit is specified for the h/t ratio.

An important change has been made in permissible bearing stresses. The distinctions between single-shear and double-shear conditions, as far as bearing values are concerned, have been dropped, and the one value now given has been raised to 45,000 p.s.i. (for a steel with a yield strength of 33,000 p.s.i.). This is in consequence of experimental data which have become available from tests of joints with rivets and high-strength bolts.

With increased unit stresses in bearing, and higher values for high-strength bolts, a word of warning is necessary with regard to the amount

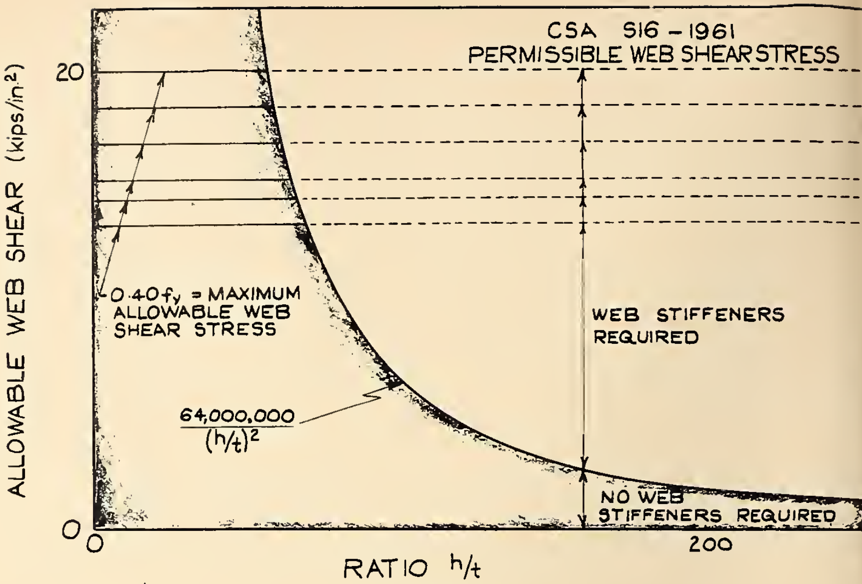
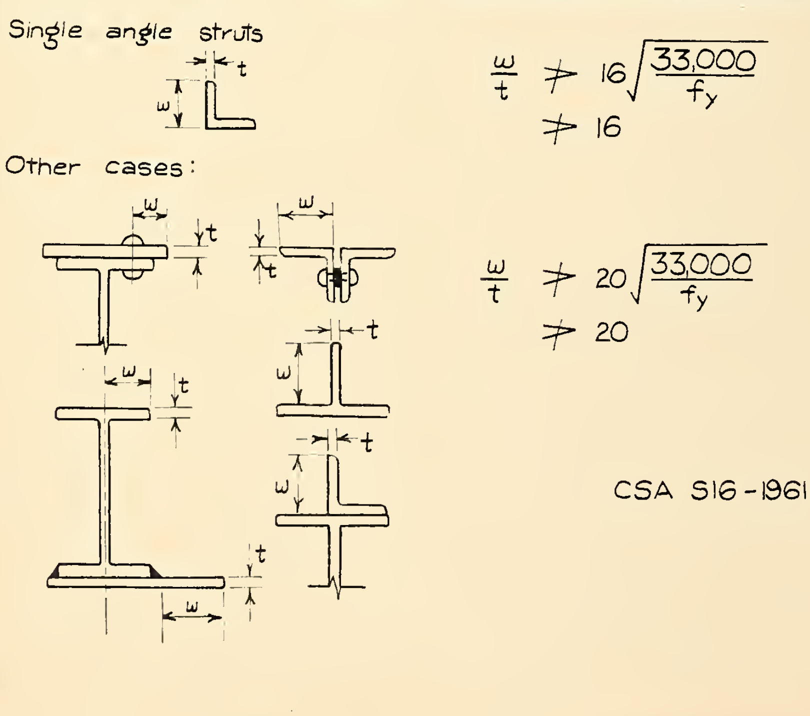


Fig. 14.

Fig. 15. Maximum width-thickness ratios for projecting elements under compression



of metal left at the end of a tension member, or at the edge of a gusset. If there are only one or two rivets or high-strength bolts in a connection, and if these fasteners carry the higher stresses now permitted, the distance between the end fastener and the end of the steel must be proportioned accordingly; a distance of one and one-half times the fastener diameter may no longer be sufficient to prevent tearing out at the end. In a later clause, (21.6), a new requirement is established for the end distance.

In the section which governs the thickness of material, some adjustment has been necessary to control the use of different steels subject to compressive stresses.The result obtained may at first sight seem strange; the higher the yield point of the steel, the greater the thickness which must be used to give stability to a given width of member. The reasoning behind such a requirement is that material with a higher yield point is usually designed at a higher working stress, but will still buckle locally at a stress dictated by its elastic modulus. The tendency to buckle must be reduced by altering the geometrical proportions of the piece, if it is to carry the higher stress safely.

The manner in which some specifications seek to guard against buckling, could conceivably penalize a high-strength steel unnecessarily; the material could be stressed at something less than its capacity, and yet have to be made up to the full thickness based on that capacity. In the case of projecting elements under compression, (Fig. 15) such as the leg of an angle, allowance may be made for an understressed element by making a fictitious deduction from the width, instead of increasing the thickness. In the case of a web or cover plate, (Fig. 16) the device has been adopted of applying a factor based on the ratio between the maximum allowable stress for the element, and the actual calculated stress in it.

Perhaps it would be well, at this point, to deal with some confusion which used to occur in the interpretation of clauses 15.3 and 21.2 in the fourth edition of S16. The corresponding clauses in the revised specification are 15.3.1 and 15.3.2, and 21.2.3. The first clauses appeared to limit the thickness of an unstiffened plate in compression to 40 times the thickness, while the second seemed to give the same limiting ratio as 32. Actually, clause 21.2 was concerned with the crosswise spacing of stitch fasteners in any unstiffened element consisting of more than one ply. The wording of both has been changed in order to make the intention clearer.

In clauses 18.8.1 and 18.8.2 minor changes have been made for an interesting reason. The term "full-milled bearing" has become "full-bearing". Some fabricating plants are now equipped with a type of saw which leaves a surface comparable with that previously obtainable only by milling, and it is felt that such technical advances should be recognized at their full value. At the same time, reference to clauses 29.8.2 and 29.8.3 will disclose that more explicit information is now given as to the quality of workmanship required in surfaces which are to bear. These changes are typical of the manner in which the specification has had to be revised in order to keep abreast of new techniques and to define more completely certain items which had hitherto been treated in general terms.

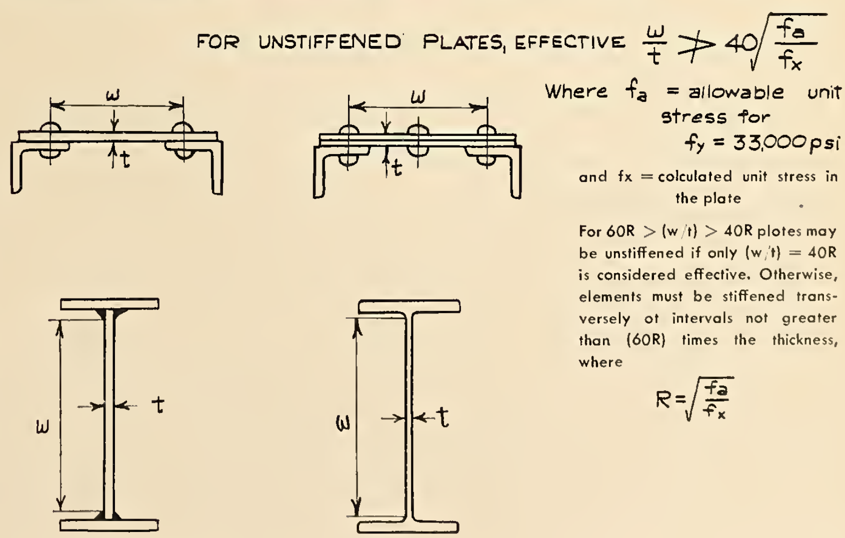
The clause regarding the proportioning of beams and girders, 22.1, has been repeated from the fourth edition, which in turn obtained it from the AISC specifications. The permission given here to use the full gross section of a flange, provided that rivet holes do not constitute more than 15% of the area, has been criticized from time to time, more recently on the grounds that it discriminates against the use of high-strength bolts in place of rivets. The original inspiration of the clause was, presumably, the idea that compression is transmitted through driven rivets, whereas it could not pass through bolts, since the latter do not fill the holes. It must be admitted that research on riveted and bolted joints gives some ground for questioning both of these assumptions, and at some later date this clause may have to be re-examined.

In the case of a plate girder with intermediate stiffeners on one side of the web only, it is now required that there be some positive attachment of the stiffeners to the outstanding leg of the compression flange. This requirement, which is to be found also in the AASHO specification for highway bridges, is intended to prevent possible failure of the compression flange by twisting.

Although it was recognized that laced, battened and perforated plated members play a lesser role in building construction than in bridge work, the committee as a whole felt that the requirements governing the design of these components should be tabled in more detail than has been done up to the present. In the part of the specification which deals with lacing systems, battens and perforated plates, it will be found, that batten plates are allowed to play a more important part, and that the information on perforated plates has been amplified. Battens, which had hitherto been regulated to a minor role, have been used in major compression and tension members in Britain and in Europe for years, since maintenance problems can be reduced when battens are used instead of lacing. The new material on the use of battens has been drawn largely from the British Standard 449—1959.

Some of the popular bridge specifications, such as those published by AASHO and AREA, contain detailed regulations for the design and detail of perforated plates, and the subject has also received the attention of the Column Research Council. Attention may be drawn to one item which might be overlooked, — that which requires the minimum width of the perforation to be not less than 8 in. This, in turn, requires

Fig. 16. Maximum width-thickness ratios for web, cover or diaphragm plates for compression members



the width of the plate to be not less than 16 in. In case this may seem unduly restrictive, it must be emphasized that there is a tendency for some designers to use perforated plates on structures of which the scale is really too small to be suitable for such a detail. There is a certain minimum hole through which the workman can reach to execute riveting or bolting efficiently, and of course there is a minimum size for any box-type member below which the ordinary tools of fabrication and erection cannot be used correctly.

The section of the specification covering open-web steel joists has been re-written. As has been pointed out in the preface, this type of member, which was originally a substitute in steel for the ordinary wooden joist, has become much more ambitious in its application. Serious thought was given to the possibility of dropping the term "joist" altogether, and referring instead to "standardized trusses". It will be found that no distinction is made between so-called "shortspan" and "longspan" joists. At one time it may have been possible to distinguish between them on grounds of method of manufacture, with the "shortspan" product being made from special sections, often with the aid of semi-automatic equipment, and the "longspan" joist being merely a welded truss built of standard angles, bars and plates. These distinctions can no longer be maintained, since from some plants there come joists of all lengths, made of uniform types of sections and assembled by uniform methods.

There remains one distinction in joist design, based on the size of the joist. Where the panel length does not exceed 24 in., bending stresses due to a uniformly distributed load may be neglected in designing the top chord. This is one detail in which S16 differs from the specifications of the Steel Joist Institute (U.S.A.), of which there is no Canadian counterpart; the SJI 1961 Specification allows this simplification for panels up to 27 in. long. It is a consideration which had its origin, apparently, in the days when the top chord of a joist supported a poured concrete slab or a wood deck in which latter case a wood nailer was fastened to the top chord. With the common use of metal deck to-day, the distribution of the load may be through bending in the top chord itself. However, within the 24 in. limit, the bending stresses are not likely to exceed the capacity of the member at the stresses now allowed, especially where the span-to-depth ratio exceeds 15 or so. Short deep joists having top chords relatively weak in bending are a possible exception. Where these are used with flexible decking consideration should perhaps be given to the effect of combined axial and bending stresses on the capacity of the top chord.

With the removal of distinctions between shortspan and longspan joists, the arbitrary limitation of joist spacing to 30 in. maximum has also been dropped. If one considers a joist as a form of truss, rather than some special type of member, this approach seems more consistent.

With joists larger than before, and spaced further apart, there has been some change in the thinking regarding the function and design of bridging. Originally the main function of bridging was supposed to be the distribution of loads laterally from joist to joist. It was then found that an important role played by the bridging was that of preventing the failure of joists by lateral buckling prior to the installation of the floor or roof. The latter is now regarded as its most important duty, and we find instances in which, for architectural reasons, bridging has actually been removed after completion of the deck. There are still types of construction, however, in which bridging may assist in the distribution of the load and the general stiffening of the floor, and certain clauses in S16 are worded accordingly.

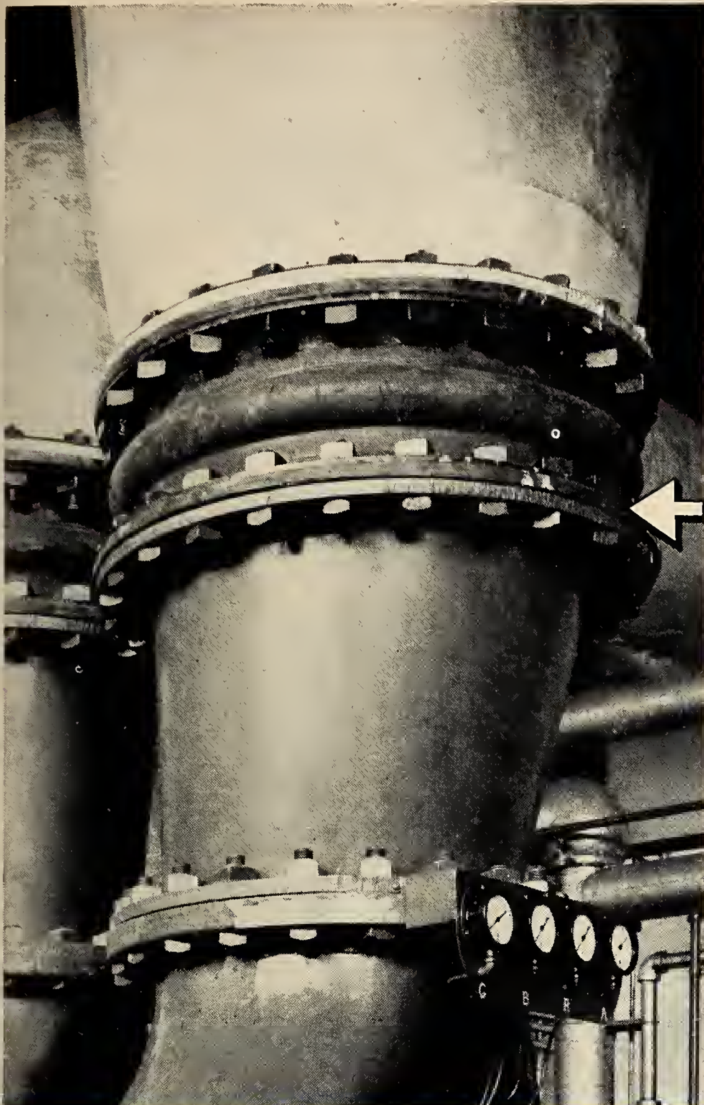
It should be noted here, that a joist is intended as a simple-span member. It may be regarded as providing lateral support for the top flange of the beam on which it rests, provided it be adequately connected for the purpose. It is not primarily intended to develop any fixed end moments, or to act as a strut, or as the anchor arm of a cantilever bracket. Yet joists have been used in these various ways in buildings. Such an extension of their application is quite legitimate, provided that they are properly designed for it. However, there is no permission to extend the design requirements, (based on the assumption of simple span, uniform loading) to special cases, without proper investigation. It may happen, for example, that the chord sections may be extended beyond the normal end of a joist to act as a cantilever, and that the projecting portion may be investigated while the effect on the first panels of the joist may be ignored. Yet an engineer or architect would never design an ordinary truss in such a manner. Let it be emphasized, therefore, that a joist is subject to all the requirements of properly engineered design when it is intended to perform functions in addition to those for which it is normally used.

The next part of the specification to be considered is the new section on Plastic Design. This design method, applied to a fixed-end beam or a continuous beam, is comparatively simple. (It is of interest to note that there was already provision in the 1954 specification for the adoption of higher unit stresses at the points where negative moments occur in such members; reference may be made, in the new edition, to clause 12.4.2.) In single or multiple portal frames, the plastic method requires more study, but may still be found simpler than the method of elastic analysis, particularly if the latter has to start from first principles. It is certainly more rational for the majority of such structures.

Acknowledgment is due to the American Institute of Steel Construction for mueh of the material to be found in section 33 of S16 (Plastic Design and Fabrication). The rules given are intended to act as a safeguard in plastic design, to remind the designer of the more important aspects of his work. As in the field of elastic design, it is assumed that the user of the specification is sufficiently well-versed in the principles of plastic design to interpret the requirements correctly. In time, no doubt modifications to some of the rules will be made as the number of plastically designed structures increases and additional research adds new knowledge.

It will be noted that for the present, it is not contemplated that multistorey buildings will be completely designed on the principles of plastic design; below the top two storeys it is required that the columns be designed according to conventional methods. Floor members may be designed plastically in buildings of any number of storeys.

This commentary has been presented with the hope that it may provide a useful back-ground to the latest edition of CSA S16 and may also, perhaps, answer some of the questions which may arise. A comparison with previous editions will show that technological advances are reflected in the various revisions and additions. It will also be observed that there are still areas in which further study of existing data, and possibly further research, are needed before the work of preparing and presenting complete guidance for the designer can be considered accomplished. In the specification there is a note saying that "suggestions for improvement . . . will be welcomed at all times". The work of writing a specification is never really finished, and the door is always open to justified revisions.



EXPANSION
CONTRACTION
NOISE
VIBRATION
END UP HERE

AT

Dominion Rubber

EXPANSION JOINTS

ENGINEERED RUBBER AND PLASTIC PRODUCTS FOR EVERY INDUSTRY

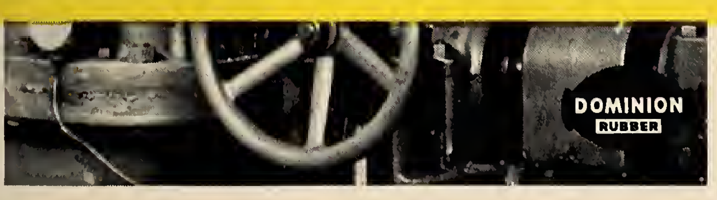
Heat, whether from environment or from materials in flow, causes piping systems to expand and contract continually. The stresses thus created often cause costly damage and down-time by buckling the piping or pulling the fittings apart. *Dominion Rubber Expansion Joints compensate for expansion and contraction — by 'breathing'.*

Pumps, compressors, and similar pulsating equipment, can't help but produce vibration and noise. And the trouble is: vibration cuts the life and efficiency of equipment, while noise sours working conditions. *Dominion Rubber Expansion Joints absorb vibration and deaden noise.*

Wear, load stresses, and settling of buildings, often move piping and equipment out of alignment. *Dominion Rubber Expansion Joints effectively handle most misalignment problems.*

So for complete information, and many case histories of better than 30 years of yoeman's service, please contact Dominion Rubber Company Limited.

MA-701



Dominion Rubber

URGENT TASKS IN ENGINEERING EDUCATION

D. M. Myers, M.E.I.C.,
Dean of Applied Science, University of British Columbia, Vancouver

DISCUSSIONS of the basic requirements for the education of an engineer always lead to controversy. They will continue to do so just as long as educators search for a complete and unique solution to their problems. This paper is written primarily as an argument against the unique solution; against attempts to put student engineers into a production line and to sacrifice the real purpose of engineering education in favour of standardization and administrative simplicity.

Our problem, briefly, is this: We try, in our various ways, to meet a number of stringent requirements in planning our engineering courses. We seek first of all to produce the 'complete' engineer who will be able to practise his profession in the broadest sense of Tredgold's definition. At the same time, we attempt to teach an individual branch of our subject to a depth which appears necessary to meet the challenge of the chain reaction of discovery which is going on around us. We yield (sometimes) to the criticism of a small but vocal band of humanists whose limited knowledge—or proud ignorance—of science leads them to deplore in scientists that lack of balance which is so evident in themselves. We sometimes react, to our own discredit, by seeing this fault in humanists as a whole, thereby widening a gulf which exists only in the imagination of a few. And finally, we feel that we have an obligation to society to economize in the time spent in education, so that our graduates will go into production as early as possible. Few industries could remain in a competitive market under such restrictions.

There are, of course, in any academic body, a few students who are able to absorb in a limited time the contents of a broad and intensive curriculum and at the same time to follow other cultural interests with considerable success. Such students deserve whatever guidance and inspiration the university can give them and should never be allowed to languish for lack of challenge. But unless admission is limited to this kind of student (and there are not many institutions where it is), the problem still remains of dealing adequately with the less brilliant but more numerous students who often eventually make the most important contributions to engineering and to the world which engineering serves. In striving to meet the needs of these latter students, we run a serious risk of neglecting the former. We need separate courses for each, with a limited amount of interchange between them. Each course would, in itself, be full and exacting, but when we try and meet the requirements of both in a single course we are unlikely to succeed in either.

In short, we are trying to pour a quart of education into a pint pot; we look on the pint pot as immutable, but not the quart; at the back of our minds is the nagging fear that the quart may one day become a gallon.

There is no complete solution to this problem. There never will be a complete solution, since the requirements of engineering education are subject to rapid and impulsive change. There are, however, a number of partial solutions, none of which is complete in itself, but which together could form the basis of a satisfactory national matrix of educational methods. If we all try to reach agreement on all our methods and put them into uniform practice, then we shall not only fail, but we shall all fall short in the same way. It is surely better for us to profit from each other's experience, but to insist on the freedom to mould our own courses to meet what we believe to be the need. Let us have uniformity where the need for it is apparent, but let us not have it for its own sake. In particular, let us avoid the kind of 'accreditation' which leads to egalitarianism and finally stagnation. There are certain essentials which must be considered in our courses; we must obviously have a reasonable standard of admission and we need a basic structure, a skeleton to support and give form to our educational methods, but the finished product need not be cast in a uniform mould.

Admission to Universities

Our starting point is the entrance qualification to our courses. Few would disagree that, up to this point, the emphasis should be on breadth of education, and engineering courses are usually planned on the understanding that freshmen can at least write intelligibly in their native tongue and preferably in one or more besides. They might be expected to have a reasonable competency in elementary mathematics, and some acquaintance with physics and chemistry, the basic sciences of their future profession. A knowledge of literature, of the history of the earth and its people, and some interest in the creative arts are all desirable, but whether these should be regarded as prerequisite is debatable. Individuals vary in the balance of their maturity, and though some have the natural ability while young to form mental images and have a memory for people, facts and events, others acquire these abilities at a later stage—possibly some years after graduation—and sometimes to a very high degree. It often needs the influence of employment or travel to stimulate a student of inanimate things to a contemplation of people and the human mind. To force this contemplation on him prematurely may delay or even prevent his full development.

Another debatable point is the extent to which the generality and breadth of courses prior to matriculation should be sacrificed in favour of more specialized study in mathematics and the physical sciences. Undoubtedly, the student who takes kindly to these scientific disciplines can enter the university with a flying start if his high school program enables him to concentrate on them, to the possible detriment of his other studies. But on the other hand, the understanding of physics and chemistry is made very much easier by a more advanced knowledge of mathematics, which is seldom attained until the first, or even second, year of a university course. More sophisticated methods of teaching then become available, and it is possible that for many students, the teaching of science at high school level can be very inefficient, however competent the teacher. The time could perhaps be better used in more general studies, leaving the real effort in science to be made at a more advanced level of mathematical knowledge. One could, of course, take this argument to the extreme and assert that a knowledge of relativity and quantum mechanics should be a prerequisite to the teaching of physics and chemistry generally. What is needed at high school level is a fine balance in the teaching of mathematics and science, and an appreciation of the wide range of human capabilities.

If there is a lesson to be learned from these considerations, it is that dogmatic adherence to rigid entrance qualifications is undesirable. There is room in a university for students with an unevenly balanced state of mental maturity at the time of entry, and their exclusion on the basis of inability to speak French or to apply Newton's laws of motion may well eliminate some of the best human material. This is not a plea for admission of the mediocre; on the contrary, more flexibility in our entrance requirements will enable us to set more exacting standards. Present failure rates suggest that this should, in any case, be done.

The University Curriculum

Coming now to university training, one cannot help feeling that the freshman, seeing the engineering curriculum for the first time, must regard it as a maze, from which he hopes to emerge within a finite time without blundering into too many blind alleys. The curriculum, is sufficient in itself to obscure the purpose of an engineering education. The reason for this lies partly in the adherence to academic traditions and catchwords for their own sake. How many engineering professors have introduced a course in drafting with the remark that 'drawing is the engineer's language'? The statement was fairly true 25 years ago; it is true only for a limited proportion of engineers today and even they, in 10 years' time, are likely to talk more through magnetic or punched tape than through drawings. This is not an argument for the elimination of drafting instruction. It is simply a suggestion that drafting could be put to better purposes than it is at present. Pictorial representation will never be displaced as a basic need in design; however, it should no longer be used as a means of transmitting detailed information that can be found in handbooks and similar publications and conveyed in codified form without having recourse to drawings.

Changes in university curricula can seldom be introduced quickly. There is usually a time-constant of several years, which serves a useful purpose in assuring a degree of stability and reaction against the pressures for change which are present in any live university. It is rarely possible or desirable to make sudden sweeping changes in curricula. The introduction of change requires a degree of opportunism, and, especially in the large or well-established engineering schools, courses are improved by a process of evolution rather than drastic surgery.

This is, of course, a safeguard to students against the zeal of well-intentioned, but sometimes too enthusiastic faculty members. However, it is an obstacle to progress, and there is a serious risk that the pace of modern engineering may be too fast for the ponderous tread of the universities. The community looks to the universities for stability in a time of change and uncertainty, and there is much to commend this way of thought. But the university's main task is to lead and not to follow, and leadership demands imagination, enterprise and experiment, as well as stability.

The big problem facing all engineering schools then is to reconcile the need for progress and change with the desire for stability and solid foundations. This task is urgent, and the first step in tackling it is to examine the difficulties.

The Early Stages of the Course

Some of these difficulties are of our own making. We have tended in the past to put ourselves in an intellectual strait jacket, following traditions which are old, but not necessarily sound. This is most marked in the earlier parts of a course. A particular case is the insistence on a uniform course for all engineering students up to the second, or even third, year of a four-year course. Few would dispute the need for generality, but this should not be confused with uniformity. There are many disciplines, both scientific and otherwise, which would be of undoubted value in the education of an engineer. For obvious reasons they cannot all be included, and a choice must be made. This is not a simple problem. It is not easy to determine, for example, whether a student will profit more from geology than history as a component of a first or second year course. It is certain, however, that the answer is not the same for all students. It is all too easy to evade the problem by prescribing one or the other, but it does not solve the problem. A university worthy of the name must not sell its intellectual clothing off-the-peg; a student is entitled to wear a tailor-made gown.

The above arguments are fully applicable only to the early years of the course; they concern the later years in a different way, which will be discussed later. They lead, then, to the suggestion that the first part

of an engineering course should provide a great deal more flexibility than is usual at present; an obvious corollary is the need for an enlightened counselling service, in which faculty members might be expected to take an active part. This is, indeed, already available in many universities, but it must be sufficiently vigorous and imaginative to retain the respect of the students.

Another debatable point is the need, if it really exists, for a crowded curriculum in the early years in an engineering school. It has been justly pointed out that the word 'school' comes from the Greek σχολή, meaning 'leisure', while 'curriculum' is the Latin for 'racecourse'. Engineering students are usually faced with a continuum of formal instruction, most of it undoubtedly good in itself, but often ineffective because the student has too little leisure to ponder and discuss. A professor is presumably chosen for his distinction in academic work. It seems a very inefficient use of his time if his lecture is immediately preceded and followed by others in different fields; all the student can take away with him usually is his set of hurriedly scribbled notes. Mimeographed summaries can help a great deal, but cannot replace the value of intimate and critical discussion.

Courses in the arts are not usually so crowded, and the library and the discussion group play a larger part in the student's life. A point which is often overlooked is that mathematics and the physical sciences in their elementary stages leave little room for debate. In the eyes of the student the professor is almost omniscient. If he proves a theorem, there is little to be gained by argument. He can explain, illustrate or amplify; he can invite students to do so and he can challenge them to find deliberately imposed errors. But his work seldom lends itself to the expression of opinions. In disciplines requiring more subjective judgment there is far more room for discussion and it is therefore easier in these areas than in engineering to make use of discussion and debate. But the difficulty of doing so in engineering makes it all the more necessary, since it is only through the exchange of views that the teacher can improve significantly on the text book.

A possible remedy is to make a drastic cut in the amount of formal instruction. One of the greatest difficulties facing students is the need to adjust themselves, chameleon-like, to four or five different environments in a single morning. This requirement is barbaric and must drive all but the stoutest-hearted into the attitude of passive frustration which many professors deplore but for which few think of accepting the blame. Admittedly, students being human beings, there are many who would not take advantage of additional leisure. Admittedly, also, this proposal would involve expense in the way of staffing, study rooms, and other facilities beyond those normally available. But a university is a place of opportunity, and there seems little argument against providing better opportunities for those who will take them than for those who will not. Competition for places in a selected group taking a more advanced, but more leisured, course might well be an incentive for the remainder, resulting in a steady growth of the 'leisure' system as more money and facilities become available.

The Senior Undergraduate Years

The senior years of the course are in a rather different category. Students are more mature and need guidance rather than tuition. Courses must be far more specialized than in the earlier years. Classes are smaller and each department is less dependent on others for 'service' courses. In general, it is probably fair to state that the pattern throughout our universities is a reasonably sound one, if considered in relation to the present structure of the courses as a whole. Since the courses are usually in the hands of individual departments, we can escape the strait jacket and are able to develop our disciplines in step with the changing face of engineering.

However, the equation of continuity has still to be satisfied. The engineer needs a higher and higher level of training to compete in the world market. More knowledge has to be acquired, and the courses are already full. Something has to give way. With a few exceptions, we cannot push anything out at the bottom of the course to make way for everything that comes in at the top. The simple answer, of course, is to call a halt to the level of undergraduate training and deal with the new material in graduate schools.

A critical examination of this solution makes it less attractive. The new educational material that comes in the wake of scientific progress is not, for the most part, of a specialized kind. On the contrary, much of it is quite fundamental and is likely to infiltrate our courses at all levels. An example of this is modern computing. The design and the efficient use of a computing machine are highly specialized matters which might well be dealt with at graduate level, but developments in numerical analysis and the changing emphasis in several areas of mathematics, the new way of thinking of engineering matters and the increasing concern with logical problems are all valuable but additional things for the student to assimilate, and should be assimilated early if their significance is to be appreciated. They belong in an undergraduate course at various levels and cannot be simply relegated to graduate study. The fact of the matter is that new engineering concepts do not pour in from the top alone; they seep in from the sides as well.

It is true that the engineering profession still demands men whose duties will tend to the administrative rather than the technical; these men have just as great a need for university education as those who are more scientifically inclined, and they may be needed in greater numbers. It would be unrealistic to suggest that, with the increasing scientific needs of engineering, all engineering graduates should be expected to have the same high level of scientific attainment. In universities which alone serve a large community, it would not be in the interest of that community to cut off the supply of competent engineers with an orthodox education and to concentrate solely on the scientific 'cream'. Where several universities serve one community, there is more room for experiment and this kind of specialization might be practicable.

However, there seems little reason why a single university engineering school should not perform both tasks. The orthodox task is being performed already and in most respects the result appears satisfactory. The need, then, is for an additional enterprise, aimed at producing the engineer with both the breadth and the depth of education to take his part in leading engineering progress in the years to come.

A Choice of Courses

An argument has already been given to show that we should not rely entirely on graduate study as a means to this end. The roots of modern engineering go deeper than that. What is required is a new additional undergraduate course which can escape the limitations imposed by the more stereotyped course of the orthodox student. It might be attempted in a small way for a start, but it should grow.

There is no clear-cut line of demarcation between the various activities of the engineer in professional practice; the blending in differing pro-

portions of many qualities, ranging from scientific insight to administrative aptitude, provides the variety of opportunity that makes successful teamwork possible. However, this very fact makes it desirable for universities to provide courses which enable their students to develop their talents to the best advantage. As a first step—where this has not already been taken—students could be divided into two streams, one of which would give emphasis to advanced technological studies with the degree of specialization required by modern engineering developments, while the other would be of a more general nature and would be directed towards the student interested more in the organization of engineering works than in the more scientific aspects of the profession.

This form of subdivision is already being made in universities in the form of 'options', usually in the later years of the course; the results, however, are offset in most cases by the persistence of the tradition of 'common' courses in two or more of the early years.

It is suggested that the students should be divided into the two streams at an earlier stage, and certainly no later than the end of the first year of engineering studies. The 'industrial' stream (for want of a better name) might well follow a course in the existing pattern, avoiding undue specialization in any one area. The 'scientific' stream, on the other hand, should be directed from the beginning into different channels, and should be given opportunity rather than formal instruction. Lectures should be limited to one or two per day, each being followed by a period of discussion or reading, and students in this stream should have in their laboratory assignments the opportunity to escape the terrible monotony which seems inseparable from laboratory instruction en masse.

Since these students will still require a general engineering education as well as advanced work in one or other area of specialization, and will at the same time be provided with time and leisure for contemplation, the course should be extended by one year. The level reached by students completing such a course could be at least that of the normal degree of Master, and it is suggested that the award of a Master's degree would be appropriate. There is no *prima facie* reason why the first degree should be that of Bachelor and there are many precedents for by-passing it. An advantage of providing a course of this nature is that the student who intends to proceed in due course to a higher degree would be able to plan his progress to that end from his early undergraduate days.

These suggestions are for the provision of challenging courses for those students who have the scientific aptitude to profit from them. There remains a large proportion of students who do not have this aptitude but are still able to cope with the demands of an orthodox course, and have other abilities which they can bring to the service of the profession. They are for the most part, indeed, the solid stuff of which the engineering profession is made, and it would be a mistake to underrate their importance. They have a rightful place in a university, but could profit more from a normal course than from the special course that we have been discussing.

Graduate Study and Research

The need for graduate study in a university is so obvious that it should need little emphasis. The tempo of modern engineering is such that continuing education has become a necessity, not only to appease the insatiable appetite of industry but also to provide source material for undergraduate courses of the future. Apart from its other uses, the graduate course is a filter which enables specialized knowledge in new areas to be sorted out and in due course to find its proper place in the more general treatment presented to undergraduates.

The place of universities in engineering research is much debated, particularly in the face of increasing research activity, often of the most fundamental kind, in industries and government laboratories, and of the size and cost of the essential facilities. In general terms, the modern trend has been to look to the large industrial or government laboratories to play the major part in research involving substantial teams of scientists and massive equipment, while the encouragement of work of the individual is left mainly to the universities. This pattern is commendable, provided that there is sufficient freedom in its interpretation. It is a mistake to regard technological research *per se* as unsuitable for universities. Technology differs from pure science only in degree; if a distinction must be drawn, it is in the underlying purpose of the work rather than its degree of erudition. The scientist is concerned with examining phenomena and discovering why they occur. His job, in short, is analysis. The technologist is concerned in synthesis; in fitting together the discoveries of the scientist and seeing where they will lead. The best results are usually achieved when the two get together.

Engineering research has been too often frustrated in the past through the unwillingness of the engineer to leave his own garden plot and trespass on the territory of the scientist. When he has done so, he has often met with conspicuous success, and it is happily becoming more common now for the engineer to lead the way into the fertile field of inter-disciplinary studies. Some of the spectacular advances in neurophysiology, for example, have come from the invasion of that field by mathematicians and engineers, and similar results are apparent in many other areas. It is too early to estimate the effect that the study of information theory will eventually have on language and verbal communication and on the psychological field of pattern recognition, which has not yielded readily to quantitative treatment; it is safe to predict that the effect will be very substantial.

It is the freedom to sail in uncharted waters which is the birthright of the universities, and this is true equally of the humanities, the pure sciences and the technologies. This is well recognized, but the universities themselves do not always provide the encouragement or facilities for interdisciplinary studies. Faculty budgets, the requirement for so many units of course work and the administrative desire for clear-cut patterns all combine to discourage the freedom which was once the very core of a university. Because of their size and increasing complexity, universities have been forced into adopting administrative patterns, and yet such patterns imply a sense of permanence and uniformity which is foreign to the higher concept of a university, especially in scientific contexts. No better words could be found to express this view than those of Dr. Caryl Haskins in his recent presidential report of the Carnegie Institution of Washington. He says: "It follows that in science, as in our larger democratic society, the individual is still a supremely important factor. In a related sense, science, like democracy, must enthrone the values of private concern, embodying and sternly defending those sectors of individual effort for which no collective element may substitute. Again science, like a democracy, has made an institution of the process of continuous reorientation, in a sense, of continuous reform. A science that is faithful to its trust, like a democracy that is true to its being, will refuse to claim that its work is ever done."

Graduate studies and research will

thrive best and individuality will flourish when artificial barriers between disciplines are withdrawn. It is suggested that in the selection of graduate students and the allocation of research funds, universities might well give high priority to inter-disciplinary studies wherever there is sufficient personal enthusiasm and ability to justify support.

Technical Education

In existing courses in most universities, there is still a large group of students who lack the ability to form physical or mathematical models for the analysis of engineering problems, or else lack the mathematical dexterity to deal with them. Their university life is a struggle which in a few cases may lead to a degree, but not to the understanding which that degree should imply. They provide most of the 'wastage' — the academic failures — and are often lost to the profession and to productive industry before they have had the chance to try their hand at it. The few who survive and eventually graduate usually enter industry and find themselves in jobs for which their training is inadequate or unsuitable. Some of them settle to their task and become valuable contributors to productive industry. Others become disillusioned and fail to make significant progress in the profession.

The questions we should ask are: Is there no course of training which would be better suited to the development of their talents? Are we, in training them in universities, guilty of continuing a most inefficient process to the detriment of the student and the university alike? Is there not a large place in industry for the *technician*, trained to fill an existing gap between the skilled artisan and the professional engineer?

Canada has a glorious tradition of *equality* of opportunity, but the tradition will lead us astray if we confuse it with *uniformity* of opportunity. These students are, in fact, being denied their opportunity by being forced into a course which will not allow their talents to be developed to the full; for, with a few exceptions, there is no alternative to the full discipline of a long and arduous university course. Many fail; the remainder receive, at best, the wrong kind of training.

This discontinuity in educational opportunity does not exist, or exists to a lesser degree, in most industrially advanced countries. The solution there lies in a network of technical colleges or institutes which offer courses suitable for the training of technicians, usually in far greater numbers than the output of professionally trained engineers from the universities. It is not necessarily true that the example of other countries should be followed in Canada, but there is nothing to be lost by seeking to combine in this country the best features of practice elsewhere. There is no doubt that in most countries of the world, whether or not we accept a distinction between the professional engineer and the technician, the boy leaving school with a view to entering one of the engineering industries has before him a choice of several kinds of training, according to his needs and qualifications. The choice is not always his own; entry to one or other course may be competitive or may demand special qualities, but at least every student will not be cast in the same mould.

The success or failure of a system of technical education depends ultimately on the recognition by industry of the value of technicians and of the fact that a man with a first-class record in a technical course will usually serve the industry far better than would the same man with a poor record at a university. The technical college, like the university, should aim at excellence, but its excellence should be in a different field. In particular, its courses would be more specialized than those of a university, and might even be more advanced within their particular area. They would not normally demand the level of mathematics and science appropriate to a university.

Above all, a technician should not be regarded in any sense as second-rate, nor should technical courses be regarded as inferior. He should not be debarred from eventual entry to the engineering profession if experience shows that he can compete successfully with professional engineers. This may, of course, confront professional associations with difficult administrative problems, but they would be the first to admit that the health of the profession and its ability to attract qualified people are more important considerations than administrative convenience.

This proposal is not new. There are already training courses for technicians in several Provinces and there appears to be reason for great satisfaction with their product. The problem is one of quantity, not quality. Too many professional engineers are employed today in work for which a university training is not only unnecessary but also unsuitable. Their positions would be better occupied by technicians trained specifically for the purpose.

There is now no lack of appreciation in Canada of the need for increased facilities for training technicians. The combined actions of federal and provincial governments, and other agencies, have led to a substantial program for the development of technical institutes throughout the country. The next few years should see the establishment of a sound and substantial foundation on which a structure of technical education may be erected. This is an excellent start, but the program must be continued vigorously if we are to achieve a proper balance of educational facilities.

Conclusions and Summary

Education is a personal matter and its essence is the communication of ideas to individuals. Universities, well aware of this fact, are facing an extremely difficult task in preserving a proper basis of education in the face of increasing enrolments and the external pressures of a changing world. Urgent action is needed to reverse the trend towards the human production line and to ensure that the products of the university retain their individuality; this is as necessary in engineering as in other studies, and can be achieved only by providing opportunities for a student to set his own pace.

Among the steps that might be taken to achieve this end are the following:

(1) introduction of more flexibility but higher overall standards for admission to universities;

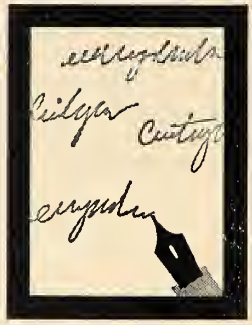
(2) provision of tailor-made courses, at least for those undergraduates who have the ability and the desire to profit from them, these courses being designed to educate engineers who might be expected in the future to advance the frontiers of the profession;

(3) encouragement of greater flexibility in research programs and increased emphasis on inter-disciplinary studies;

(4) provision of more widespread courses for training technicians and increased recognition of them by industry.

Above all, if engineering is to play a vital part in the years to come, we must provide opportunities for the man who is different. There is a grain of truth in the saying that 'men are born equal, but some are more equal than others'. If, for economic reasons or for sheer necessity, we must accept a certain degree of regimentation of students, let us at least accept it with a bad grace as a necessary evil and not as an end in itself.

Abstracts



Papers to be presented at the 1962 EIC Annual General Meeting

Following are the remainder of the abstracts received in time for publication prior to the Annual General Meeting. Other abstracts appeared in the April and May issues of the Engineering Journal.

AGM Paper #68

Absolute Measures of Work Management

w/c A. B. Howell,
Staff Officer Aeronautical Engineering,
Training Command Headquarters, Winnipeg

Standards of work management and performance are usually established by comparison, i.e. the best demonstrated performance from a group of units is commonly accepted as the unit standard. This technique is probably effective in the long run in evolving better techniques of work and work management, but it is an empirical process, and its course towards ultimate limits of performance is uncertain because it lacks analysis.

Discrimination, control and direction of work would be more certain and precise if absolute standards rather than purely comparative standards were available. In this paper attempts are made to develop performance standards that are as independent of arbitrary considerations as possible. Two categories of work are considered.

The first category of work is that which is conditioned by probability. The example which is developed in the paper is the repair of aircraft in RCAF Maintenance. The technique of analysis used is Queuing Theory.

In applying this technique the following conditions and assumptions apply:

(a) a random occurrence of events (breakdown) in time
(b) an arrival coefficient (λ) that varies inversely with the numbers of serviceable machines (aircraft)
(c) a random distribution of repair times
(d) the number of crews is considerably less than the total number of machines (aircraft)
(e) first come is first served
(f) the population (total number of aircraft serviceable and unserviceable) is finite

The second category of work is that which is dependent on the coordinated efforts of workers or groups (crews) of workers. Such a collection of individuals or groups must always depend in some degree upon the joint use of facilities. The joint use may be reduced to a very low level providing the expense of providing multiple facilities can be afforded, but some interaction between units remains, if only by the occupation of neighboring space. On this account some element of interference must always develop wherever groups or individuals are required to work together in a single organization. To resolve this interference, and minimize its effect upon production is one of the prime tasks of the supervisors.

The example of coordinated work developed in this paper is the performance of aircraft periodic inspections by inspection crews in RCAF Maintenance. The technique of analysis is based on the concept of Organizational Entropy in which the degrees of team coordination are measured in terms of organizational entropy difference.

By the concept of Organizational Entropy the work done by the work supervisors in coordinating the output of a number of workers or crews of workers is absorbed in resisting the natural tendency of a state of organization to disintegrate and lose its coordinated form. Thus a collection of crews or individuals tends to increasing chaos, i.e. increasing entropy; and the supervisors spend their energy in containing this tendency i.e. reducing entropy.

AGM Paper #56

Engineers in the Canadian Economy

J. P. Francis,
Director, Economics and Research Branch,
Department of Labour, Ottawa

Canadian economic development is imposing some important changes on requirements for engineering manpower and on how such manpower is utilized.

Jobs for engineers have been growing at a more rapid pace than total employment for several decades, but in the last ten years a significant change has occurred in the factors determining this growth. Until the 1950's, engineering manpower requirements came mainly from the overall growth of the economy and the fact that the industries already employing engineers were, by and large, the fastest growing ones. Since about 1950, the continued growth of engineering manpower needs has been primarily due to the greater employment of engineers by industries in which they were already well established.

In sharp contrast to earlier decades, there have been substantial increases over the past ten years in the proportion of engineers in the work forces of many industries. Needs for engineers, which before were mainly the product of the sheer growth of industry, are now being generated primarily by the changing character of industry due principally to technological developments.

In the past, fairly extensive facilities have been developed in Canada for the education of engineers while very limited ones were provided for the training of technicians and the education of business, financial and organizational specialists. As a result, engineers have been em-

ployed extensively in all of these fields. Now, however, facilities are being expanded rapidly for the training of technicians and at the university level for a growing number of social scientists and others with special preparation for the business world.

These two basic trends, in the character of requirements for engineers and in the availability of other related kinds of works, will have important effects on the engineering profession. The crucial importance for economic development of science and technology, and the growing complexity of scientific knowledge, are placing a premium on engineers with post-graduate training and increasing the likelihood of other engineers becoming technically obsolete. Thus greater emphasis in future will need to be put on the development of university facilities at the post-graduate level in the engineering field. In addition, more attention will have to be given to the development of ways and means whereby engineers already in the labour force can keep abreast of technical and scientific developments.

To the extent that engineers are employed on subprofessional technical work, the growing availability of technicians will undoubtedly change this pattern of utilization. As a greater number of bright people start to come from university courses oriented to the needs of business and commerce, engineers will find themselves in intense competition with such people. Both of these pressures will generate further basic changes in the engineering profession. No longer will engineering education to the same degree be primarily a valuable general preparation for a wide range of employment, both technical and non-technical. An extensive understanding of scientific principles on top of which is built some specialized technical knowledge will increasingly be the characteristic of the profession. The engineer of tomorrow therefore may be quite different from the engineer of today.

AGM Paper #28

Loss Measurement in Magnetic Steel Above Saturation Density with Controlled Flux Waveform

J. S. MacKelvie,
Electronics & Electrical Engineer,
Canadian General Electric Co., Peterborough
H. Hollitscher,
Laboratory Engineer,
Canadian General Electric Co., Peterborough
E. C. Elgar,
Mechanical Engineer,
Canadian General Electric Co., Peterborough

Standard methods of measuring loss in magnetic steel provide information in a form which is not particularly suitable for modern rotating machine design nor of adequate range.

This paper describes a means of producing controlled flux waveforms in standard steel samples over a range of flux densities encountered in practice. A calorimetric method of measurement of loss is used successfully to avoid the difficulties associated with the electrical measurement of loss at saturation flux density.

The equipment is capable of magnetising the steel to a peak magnetic field strength of 2500 Oe. (approx. 5000 AT/in) with a fundamental frequency in the range 30 - 90 c/s and a flux distortion of less than 5%. Harmonics up to 2000 c/s can be superimposed on the fundamental. An alternative means of operation can control the waveform of the magnetic field in a yoke designed to give a uniform axial field at the highest magnetic field strength. Steel samples can be located rapidly on the axis adjacent to search coils which are used to measure peak magnetic flux and peak magnetic field strength.

The yoke is excited by a tube-transistor amplifier system employing overall negative feedback. By this means the flux distortion due to steel saturation is considerably reduced.

Measurement of peak flux density is made with an average reading voltmeter attached to a search coil which is compensated for air leakage flux. Peak magnetic field strength is measured with another search coil.

Loss is determined by calculations from the measured rate of temperature rise on the steel surface using thermistors. The change in thermistor resistance due to heating is sensed in a bridge and serves as a measure of the rate of heat generation.

An example of the results obtained in the frequency range 30-660 c/s is presented.

AGM Paper # 59

The Mechanical and Electrical Services for the Place Ville Marie Development, Montreal, Quebec

M. Kert, P.Eng.,
Jas. Keith & Associates

The Place Ville Marie Development is a seven acre commercial complex in Montreal. It essentially comprises a base of two floors of garage and storage areas and a shopping promenade, plaza, plaza shops, 40 storey Royal Bank of Canada office building, 4 Royal Bank quadrants, 3 storey Cathcart office building with shops at plaza level.

The largest building in the Project is the 40 storey Royal Bank Building. The mechanical services are located in the lower mechanical floor and the upper penthouse. The building has a fireproof steel frame, "Q" floors, aluminum curtain walls, single glass windows, removable metal panel accoustical core ceilings, recessed fluorescent lights and diffusers, and thirty-two elevators. 6000 tons of refrigeration are provided for cooling. The perimeter has an induction air conditioning system and the interior spaces a medium pressure air system.

Steam is supplied to the project by the C.N.R. at 400 psi. and is reduced to 30 psi. for final use.

Domestic water supply is provided from the city water lines by two 8" services from University Street. The water is stored in a concrete tank located at track level, and is pumped directly to the Cathcart building and to house tanks on the 27th floor and upper mechanical penthouse of the Royal Bank Building. The lower levels are fed directly from the street. Uppermost floors and the observation tower of the Royal Bank Building are fed by a hydropneumatic system.

City connections are provided from University and Mansfield streets to feed a ring main at the lower levels for sprinklers and fire hoses. Two 2000 gal. 100 psi. pumps, one diesel and one electric, taking suction from the concrete tank at track level provide secondary service water for the lower levels and track platforms. The Royal Bank Building is provided with primary water for fire protection from the two previously mentioned house water tanks, and secondary protection from one diesel and one electrical fire pump, each rated at 750 US gpm vs 100 psi. This fire protection is supervised by a coded electrical system.

The C.N.R. track area has an exhaust ventilation system to remove fumes from the diesel engines and discharges this air to atmosphere at the roof of the Cathcart building. The garage areas have supply exhaust ventilation to control carbon monoxide concentration and remove gas fumes and discharge air to atmosphere at the roof of the Cathcart building. Store areas are air conditioned with individual fan coil compressor units provided with cooling tower water from two towers located in the roof of the Cathcart building.

Hydro service is supplied to the site from 12 kv. 3/60 service, and drops to a main switchboard and metering room at track level. 12 kv. feeders rise to the lower mechanical floor of the Royal Bank Building and the second mechanical penthouse, and feed four transformer banks of 5000 kv. each. 12 kv./550/3/60/. Feeders serve two electrical closets on each floor of the tower. Dry core 500/120/208 transformers and panel-boards and metering facilities are provided in each closet. Separate transformer banks and substations are provided for the Lower Areas and for the Cathcart building. Provision is made for the metering of tenants.

Emergency power for the lower levels is provided by a 500 kv. diesel. A 1000 kva turbo-generator is provided for emergency power for the Royal Bank Building. The total connected load is 36,000 kva.

AGM Paper # 3

The so-called Shear Strength of Concrete Beams

Dr. G. J. Kani
Associate Professor, Department of Civil Engineering, University of Toronto

The practical aspect of the problem in question are: (a) when is it necessary to use additional reinforcement in a reinforced concrete beam in order to prevent a so-called shear failure,
(b) where to place this reinforcement,
(c) what kind of reinforcement to use.

The answers to these questions may be found only by investigating and understanding the internal mechanism of the so-called shear failure.

Shear stress is obviously a very unsuitable indicator of diagonal failure, not only because there is no "shear strength of concrete" to compare with, but even more because shear stress is only one component of the total stress and by far not the largest one.

The internal mechanism of diagonal failure for an R.C. beam without and with bond has been developed and by means of it, it was shown that the so-called shear failure is a problem of diagonal compression failure.

Four different causes of failure seem possible: (I) Due to narrowing of the compressive zone, Ia. overstress in the compressive zone (flexural failure), Ib. splitting of the compressive zone.

(II) Due to "transformation of the beam" (breaking away of the "concrete teeth"), IIa. anchorage failure, IIb. buckling of the remaining arch.

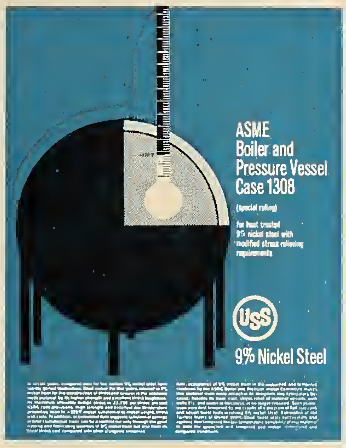
To investigate the relation and the possibility of these four types of failure a series of tests has been started at the University of Toronto. Because the different parameters of failure cannot be controlled in conventional full beams, additionally to full beams, part beams were investigated. By changing the conditions, the order of the different types of failure could be determined. Thus the factor of safety of 2.0 has been obtained for diagonal failure, (Type Ib), and 2.7 for flexural failure (Ia). Anchorage failure occured at 2.8 and with the improved anchorage, the factor of safety was again increased considerably. In order to obtain the upper limit of pure diagonal compression, a part beam was tested thus reaching a safety factor of 4.5.

The investigations are going to be continued.

New in Cryogenics —
USS 9% Nickel Steel, quenched and tempered, now permissible without stress-relief!

ASME Code Case 1308. Important changes in the ASME Boiler and Pressure Vessel Code, Section VIII, were approved in April, 1962. The major changes permit 9% nickel steel up through 1¼″ incl., quenched at 1475°F and tempered at 1050° to 1125°, to be used in the construction of welded cryogenic pressure vessels *without* stress-relieving the completely fabricated vessel.

Both revisions, as outlined in Case 1308, will give 9% nickel steel new economic advantages for fabricating a wide variety of equipment for extremely low-temperature applications. Included are pressure vessels, piping, flanges, valves, and other "hardware" used to produce, transport, and store liquefied gases at temperatures as low as —320°F.



Previously, ASME required heat treatment of 9% nickel steel in accordance with ASTM A-353 which calls for double normalizing at 1650°F and 1450°F and stress-relieving at 1050°F after welding.

10 to 15% savings possible. A comparison of costs for a large land-based liquid methane storage vessel of 80,000-barrel capacity indicated a potential savings of at least 10% in the total erected cost through the use of quenched and tempered non-stress relieved 9% nickel steel.

In vessels of these capacities, stress-relieving costs are prohibitive. The elimination of post-fabrication thermal treatment in thicknesses through 1¼″ will be a major factor in reducing the cost of cryogenic storage utilizing 9% nickel steel. Furthermore, the use of quenched and tempered plates provide an additional $30 per ton savings over the previously specified double-normalized and tempered 9% nickel material. These factors plus high strength, weldability and toughness make USS 9% Nickel Steel the most economical material for temperatures down to —320°F.

Higher allowable design stress. 9% nickel steel now has an allowable working stress up to 23,750 psi permitting its use in thinner, lighter weight sections with no sacrifice in safety.

Superior low temperature service. The results of "Operation Cryogenics" field tests in 1960, showed that quenched and tempered USS 9% Nickel Steel displayed high yield strength and excellent toughness at —320°F. For a copy of the new **ASME Code Case 1308** (pictured above); specifications for 9% nickel steel; or for a USS 9% Nickel presentation including our film, "Minus 320°," write to United States Steel Export Company, Royal Bank Building, Toronto, Ontario. USS is a registered trademark.

USS

United States Steel Export Company

TORONTO • MONTREAL • WINNIPEG • CALGARY • VANCOUVER

Steel For maximum strength . . . toughness, safety

Month to Month

E.I.C. ELECTIONS AND TRANSFERS

Applications through Associations

By virtue of the co-operative agreements between the Institute and the Associations the following elections and transfeers became effective April 14, 1962.

SASKATCHEWAN

STUDENTS ADMITTED

E. J. Andrews, W. B. Arnesen, B. M. Art, R. J. Assie, R. E. J. Bachelu, G. C. Bates, D. C. Bellows, R. K. Benneweis, A. F. Bessel, K. D. Bolt, K. J. Brisbin, R. G. Bross, K. E. Cameron, L. M. Carlson, G. W. Carter, T. Cheberiak, A. R. Clark, T. G. Clarke, D. L. J. Crabb, A. G. Culham, A. E. Dahlman, K. S. Dhaliwal, R. A. Dion, N. M. Dircks, L. Domshy, D. R. Drummond, R. W. Ecker, H. A. Engel, D. J. Ewert, H. L. Filson, L. Frankenberger, L. Fraske, O. H. Friesen, G. A. Fuller, H. Ganter, D. A. Gemmill, A. R. Gerbrandt, D. L. Gordon, T. H. Gorkoff, R. L. Graham, J. P. Hagan, L. P. Hakl, J. M. Helfrich, E. J. Hinz, W. R. Hartt, G. A. Hitchings, R. D. Hofer, R. A. Hoffman, J. W. Holmes, J. M. Hoover, R. Hrywniak, A. R. Iverson, M. G. Johnson, R. J. Karpa, L. J. J. Kasmar, N. A. Kopperud, J. R. Kowalishin, E. P. Krip, D. D. S. Lang, G. A. Lawson, G. T. Leader, B. S. Lesiuk, D. G. Loehr, W. G. Longman, N. Lucyk, D. G. Lukan, P. J. MacDonald, D. L. Mader, P. M. Maher, D. A. Malley, J. K. Mann, L. S. Manz, J. R. McCorkell, S. R. McCrimmon, R. A. McDonald, N. W. McGrath, D. C. McLaughlin, B. N. McLean, D. B. McLean, G. E. McLean, V. M. Meek, P. I. T. K. Mjolid, G. A. Morrison, W. M. Nahirney, W. J. Newis, J. J. Q. O'Brien, G. T. Olinyk, R. L. Piché, J. Pidwerbesky, E. M. Piedt, J. D. Poliquin, L. G. Powell, R. D. Putland, N. R. Pillai, D. J. Reiter, R. P. Rigelhof, R. R. Rodgers, D. E. Rose, G. W. Runolfson, V. H. J. Savoie, V. Schmegelsky, J. H. Schneider, J. G. Schram, A. C. Schreiner, G. F. Schuster, W. A. Scott, R. R. Sedler, D. C. Semkin, V. J. Sentis, R. A. Serné, D. R. Shenton, R. D. Silverthorn, H. Siwak, L. G. Smith, M. M. Smith, D. W. Snodgrass, L. G. Sokolon, W. L. Sorensen, L. B. Spiess, K. E. Stangland, J. Staseson, J. M. Stone, A. V. Sulma, M. N. S. Swamy, R. F. Thurm, D. C. Towle, J. T. Undershute, B. E. Urbanoski, E. W. Verigin, D. C. Waind, M. P. Wenkoff, K. G. Wetterstrand, C. G. White, J. C. Wiebe, E. J. Yee.

NEW BRUNSWICK

Affiliate to Member: R. P. Puddester.

REPORT OF THE ADMISSIONS COMMITTEE

A number of applications were presented for consideration and on the recommendation of the Admission Committee, the following elections and transfers were effected at a meeting of council on April 14, 1962.

Members: P. B. Aitken, Montreal; W. H. Arison, Walkerville; F. J. Artner, Toronto; J. J. Asselstine, Falconbridge; J. Bar, Montreal; H. J. Bernat, Montreal; C. A. Bunting, Don Mills; G. E. Caswell, Cardinal; J. Dumas, Montreal; C. Festing, Woodstock; F. Gavsie, Montreal; W. R. Geiger, Montreal; R. M. Gooderham, Toronto; W. L. Haney, Ottawa; S. H. Husain, Sudan; P. R. Jeffcoate, England; J. C. Jofriet, Toronto; I. Kallos, Vancouver; G. T. Kaneb, Cornwall; R. F. Kilmartin, Topeka, Kansas; R. W. Knight, Brampton; E. Lanfranco, Montreal; G. S. Larocque, Montreal; J. W. Libby, Vancouver; K. L. MacCharles, Winnipeg; A. R. MacKenzie, Ottawa; R. E. McBurney, Ottawa; G. McGregor, Port Hope; S. R. Martin, Kingston; G. E. Martyn, London; S. K. Mathur, Montreal; F. B. May, Montreal; M. Parker, Montreal; R. S. Patton, Port Cartier; G. A. Rankin, Port Credit; O. W. H. Roberts, Victoria; J. W. Robinson, Don Mills; B. A. Saharov, Montreal; D. A. Selby, Montreal; A. Soosar, Montreal; W. J. Spain, Hamilton; H. L. Thompson, Edmonton; P. von Bulow, Brampton; J. G. White, Sault Ste. Marie; D. F. Witherspoon, Guelph; R. Yong, Montreal; H. G. Zimmerling, Montreal.

For Admission as Associate Member: E. W. Burgar, Thailand; I. D. Carnegie, Scarborough; W. R. F. Duffell, Calgary; R. D. Eaton, Levack; T. D. Ferguson, Venezuela; A. H. Francis, Montreal; L. D. House, Toronto; M. E. Kilfoil, Saint John, N.B.; D. I. MacLeod, Calgary; Y. Moshi, Montreal; D. J. Senior, Montreal; H. J. Thorburn, England; D. C. Wong, Vancouver.

For Transfer from Associate Member to Member: T. G. Bowie, Toronto; W. L. Larson, Montreal; D. M. Shah, England; N. Toye, Hong Kong.

For Transfer from Student to Member: J. S. Crispin, Montreal.

STUDENTS ADMITTED

Ecole Polytechnique: B. F. Ashkar, M. Bastien, P. Belanger, G. Bertrand, P. Bhéreur, J. P. R. Blais, J. P. Boulich, J. P. Bourdages, J. G. P. Cabana, J. P. Caza, A. Charbonneau, D. Coté, A. Couvrette, J. A. R. Crevjer, A. J. DeBroux, J. A. R. de Grandpré, R. del Salvador, R. Dervaux, J. A. G. Desrochers, R. Dionne, G. Dupont, J. J. Dupré, B. A. Genest, J. Gosselin, V. Gravel, P. M. Gremeaux, G. L. Grenier, M. Grenier, G. Grignon, G. Guay, D. Haccoun, P. Heynemand, J. E. G. Houle, G. Juneau, D. P. Labelle, P. P. Labelle, C. Lachance, J. P. Lacoursiere, A. Lafontaine, G. Lamontagne, M. Lamontagne, J. Lamy, A. Lanctot, L. H. J. P. Lariviere, L. Lavertu, C. Leblanc, J. M. Loignon, P. Malepart, E. Maloney, G. Patenaude, G. Payette, G. Pesant, S. Ricard, J. P. Roberto, J. C. Rodrigue, J. Rompre, J. H. Roussy, P. St. Onge, G. Soulieres, L. Sziladi, O. Talbot, B. Talerman, R. Theoret, P. A. White.

Queen's University: C. F. Blair, K. H. Boegh, D. M. Bruce, J. C. Burnett, R. A. Copp, I. W. Davidson, K. D. Does, E. Exley, G. B. Fenton, J. B. Gilmour, D. B. Graham, J. W. Green, W. K. Lee, B. C. Mitchell, P. B. Perrin, R. T. Popple, J. D. Rannie, E. V. Ryczko, D. H. Smith, S. W. Spero, P. J. Spooner, R. L. Streich, I. D. Thom, R. J. Twigg, J. M. Van Brunt, O. J. Weber, E. J. Woolsey.

St. Mary's University: D. E. Borde, A. A. MacDonald, I. R. de Verteuil.

Royal Military College: J. M. J. L. Filion, T. H. Phelan, A. J. Rodger.

University of Toronto: D. C. Newton, I. C. P. Sturdee.

Mount Allison University: D. G. M. Scott.

University of Alberta (Calgary): D. J. Aitken.

McGill University: R. D. Brodie.

Assumption University of Windsor: J. F. Dalgleish.

Coming Events

The Engineering Institute of Canada. 75th Annual General Meeting. Montreal. June 12-15.

American Nuclear Society. Eighth Annual Meeting, Boston, Mass. June 17-21.

American Chemical Society. Division of Medicinal Chemistry. Eighth Annual Medicinal Chemistry Symposium. Boulder, Col. June 18-20.

Canadian Society of Agricultural Engineering. Annual Meeting. Ottawa. June 18-20.

American Institute of Electrical Engineers. Summer General Meeting. Denver, Col. June 18-22.

Institute of Electrical Engineers. Summer Meeting. Mersey, England. June 18-22.

The Chemical and Petroleum Engineering Exhibition. Olympia, London, England. June 20-30.

American Society for Testing Materials. 65th Annual Meeting. New York. June 24-29.

Institute of Radio Engineers. Sixth National Convention on Military Electronics. Washington, D.C. June 25-27.

American Society of Heating, Refrigerating and Air Conditioning Engineers. 69th Annual Meeting. Miami. June 25-27.

Institute of Radio Engineers, American Institute of Electrical Engineers, Instrument Society of America, American Society of Mechanical Engineers, American Institute of Chemical Engineers. Joint Automatic Control Conference. New York. June 27-29.

Gordon Research Conference on Statistics in Chemistry and Chemical Engineering. New Hampton, N.H. July 30-August 3.

American Society of Mechanical Engineers, American Institute of Chemical Engineers. Fifth National Conference on Heat Transfer. Houston. August 5-8.

Engineering Institute of Canada, Ottawa Branch, Ottawa Valley Golf Meet in celebration of the Institute's 75th Anniversary. Arnprior Golf Club, June 15.

Personals

Benoît Baribeau, M.E.I.C. (Ecole Poly. '43), Assistant to the President, Defence Construction (1951) Limited, Ottawa, has been named General Manager of Engineering at Quebec Hydro-Electric Commission. Mr. Baribeau's experience includes positions as assistant to the plant engineer at the Montreal East plant of British American Oil Co. Ltd.; resident engineer on various projects with the consulting firm of Surveyer, Nenniger and Chênevert; and as branch manager for Quebec and director of European operations in Paris for Defence Construction (1951) Limited.

Hugh E. Seely, M.E.I.C. (U.N.B. '47), former chairman of the Hamilton Branch of the Engineering Institute of Canada, has been appointed General Sales Manager of Robertson-Irwin Limited, Hamilton. Mr. Seely has had extensive sales management experience, and for the past few years he has managed the company's Toronto District Office.

Leo Roy, M.E.I.C. (McGill '32, Poly. '30) General Manager, has been appointed Executive Assistant to the President at Quebec Hydro-Electric Commission. Mr. Roy was associated with Shawinigan Water and Power Company, and with the Quebec Power Company for 14 years until 1946, when he joined Hydro-Quebec. Mr. Roy was former Chairman of the Montreal Branch of the Engineering Institute of Canada. He is vice-president of the Engineers Confederation Commission.

Glenn H. Curtis, M.E.I.C. (Toronto '48) has been elected President of Stone & Webster Canada Limited. Mr. Curtis is the first Canadian to hold this position. Mr. Curtis joined Stone & Webster in 1955.

Howard Campbell, M.E.I.C. (McGill '40) has been promoted to Vice-President, Manufacturing at Canada Starch Co. Ltd. Mr. Campbell has been manager of the company's plant at Cardinal, Ont. since 1957, and will continue in this post. Mr. Campbell joined the company in 1949.

J. D. Chisholm, M.E.I.C. (McGill '23) has retired as Manager of the Filling Division of Canadian Arsenals Limited, after 16 years as head of the Crown owned munitions plant. Mr. Chisholm held the position of Production Manager of Ammunition Filling plants for Defence Industries Limited during World War II. Mr. Chisholm joined the Engineering Institute as a student in 1922.

Col. William A. Capelle, C.D., M.E.I.C., P.Eng., (Manitoba '32), of Ottawa, has been named Special Assistant to the Assistant Deputy Minister, (Construction Engineering and Properties) in the Department of National Defence.

G. L. Baneroft, M.E.I.C. (U.B.C. '50) has been appointed manager, Western Division for S.W. Hooper & Co. Ltd. Mr. Bancroft's experience includes eight years in the pulp and paper and allied industrial machinery sales, as well as mechanical contracting, and four years in technical sales and service with a major Canadian chemical company in Western Canada.

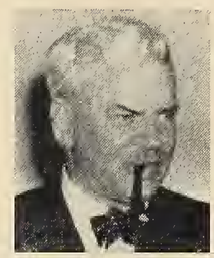
J. W. Hieks, M.E.I.C. (Toronto '59) has been appointed Regional Engineer for the Central Region of International Underwater Contractors Limited. Mr. Hicks' duties will involve all facets of IUC's construction, as well as underwater consulting activities, which will encompass both the municipal and marine construction fields. Mr. Hicks will be located at the firm's offices in Scarborough, Ont.

L. A. Prudhomme, M.E.I.C. (Ecole Poly. '44), Maintenance Superintending Engineer, Regional Operations Division, has been named General Manager, Supply Services at Quebec Hydro-Electric Commission. Mr. Prudhomme joined Hydro-Quebec's Industrial Department in 1948 after four years at the Beauharnois power house, and was appointed Regional Manager of its Northwestern Systems in 1950. In 1955, he became Maintenance Superintending Engineer.

Yvon De Guise, M.E.I.C. (Ecole Poly. '37), Assistant Chief Engineer, Regional Operations Division, has been named General Manager, Operations and Sales at Quebec Hydro-Electric Commission. Mr. De Guise joined Hydro Quebec in 1945, and has held positions as Operations Engineer at Beauharnois; Superintending Engineer, Operations of Power Stations. He was a member of the working committee which prepared the control and regulation plans for the St. Lawrence River, and is now a member of the International St. Lawrence River Board of Control.

Obituaries

Wilfrid Abell, M.E.I.C. died February 26, 1962 in Winnipeg. Mr. Abell was 61. He was born in Keewatin, Ontario and came to Winnipeg in 1937. He became a member of the Engineering Institute of Canada in 1952. He is survived by his widow, a daughter, two sons and four grandchildren.



James Bertram Hayes,
M.E.I.C.

James Bertram Hayes, M.E.I.C. (N.S.T.C. '16), President of the Engineering Institute of Canada in 1946, died May 21 at Halifax. He was in his 70th year.

Mr. Hayes was born at Springhill, N.S., and received his education there and at Mount Allison University, Dalhousie, and Nova Scotia Technical College. Immediately after graduating in 1916 he joined the Canadian Field Artillery, and he served with the C.F.A. and the Royal Canadian Engineers until 1919.

From 1919 until 1929 Mr. Hayes held a variety of positions in the utility field in the United States and in Jamaica, and returned to Canada to become the general manager of the Nova Scotia Light and Power Company at Halifax. He retired in 1948.

Mr. Hayes joined the Institute in 1920 and subsequently served on the executive committee of Halifax Branch. He also served as president of the Canadian Electrical Association, the Halifax Board of Trade, and the Canadian Transit Association.

During his career Mr. Hayes was an active participant in local and provincial affairs.

Survivors include his wife and a son.

(Continued on page 129)

MESSAGE FROM THE PRESIDENT

THE ENGINEERING INSTITUTE of Canada stands at an historic milestone in its progress. Behind us lie the 75 years it has taken to reach this year, the Institute's Diamond Jubilee. Ahead is a great adventure: the opportunity to serve Canada in far greater measure than we have ever done before.

THE SEVENTY-FIVE years which have brought us to this milestone have witnessed the building of a great institution, the Engineering Institute of Canada. Our Institute is founded on the solid rock of engineering achievement which has made this land what it is—the home of free men, not afraid of hard physical labour, but with the value of that labour mightily enhanced, thanks to the great power developments, transmission systems and distribution networks which bring electric service to virtually all citizens; thanks to the railways, waterways, highways and airways which permit easy travel almost everywhere; thanks to the telecommunications systems which not only knit the cities, villages and farms of Canada together, but also join us to our fellow men around the world; and thanks to our great forestry, mining and manufacturing enterprises which have provided Canadians with a high standard of living, largely by enabling us to enjoy a notable role in world markets.

BUT THIS is not sufficient. We cannot rest on our laurels, because we have not yet looked to our obligations as we should.

WHAT ARE these obligations? I think they are included in these aspects of the life of a truly professional engineer:—

1. Each engineer should add his strength to that of his professional fellows by participation in the activities of the voluntary, professional, technical society of his choice. I hope it is the Engineering Institute of Canada.
2. Each engineer should make available to the community in which he lives the balanced, deliberative counsels he is so well qualified to give.
3. Each engineer should play such role as he can, effectively, in the collective deliberations of our country, the role for which his training as an engineer qualifies him.
4. Each engineer should recognize his responsibility to the Canadian community by building up the engineering heritage our professional forebears bequeathed us.
5. Each engineer should strive to make the maximum contribution he can towards a full understanding of the problems of our fellow men in the under-developed countries: towards helping them to help themselves.

I KNOW that if we, as Canadian engineers, will put our shoulders to the wheel in the way I have indicated, the next 75 years will be bright, worthy of the heritage we have received. Let us be worthy of it.

FOR MY PART, I am humble indeed in recognition of the great honour you have done me in electing me to that office which so many great Canadian engineers have filled. As your President, I hope I can contribute, in some small measure, towards making the Engineering Institute of Canada capable of even greater service to our Country and to our fellow men.

F. L. Lawton

F. L. Lawton, M.E.I.C.
President, 1962-1963

MESSAGE DU PRÉSIDENT

L'INSTITUT CANADIEN DES INGENIEURS atteint une étape historique de son existence. Derrière lui, s'étend le chemin parcouru jusqu'à l'anniversaire qu'il fête cette année: 75 ans! Devant lui, c'est une perspective riche de grandes possibilités: l'occasion de servir le Canada comme jamais encore l'Institut n'a pu le faire.

CES 75 ANNEES ont vu s'édifier une grande institution: l'Institut canadien des ingénieurs. Celui-ci repose sur une base solide, celle des réalisations techniques qui ont fait de notre pays ce qu'il est: une patrie d'hommes libres ne craignant pas le dur labeur physique mais conscients de l'aide incomparable que leur apportent les grandes réalisations techniques de notre époque: centrales électriques, réseaux de transport et de distribution qui mettent à la disposition de presque tous les citoyens les merveilles de l'énergie électrique; chemins de fer, voies d'eau, routes, lignes aériennes qui rendent nos déplacements si faciles; systèmes de télécommunication qui relient les uns aux autres non seulement nos cités, nos villages, nos fermes, mais multiplient les contacts avec l'humanité toute entière; enfin, nos grandes industries forestières, minières et manufacturières qui ont assuré aux Canadiens un niveau de vie si élevé en même temps qu'ils leur permettaient de jouer un rôle important sur les marchés mondiaux.

MAIS CELA ne suffit pas. Nous ne pouvons nous reposer sur nos lauriers, parce que nous n'avons pas encore rempli toute notre tâche ni accompli tout ce qu'on attend de nous.

QUELLES SONT nos obligations? En voici quelques-unes, et je crois qu'elles font partie intégrante de l'existence du véritable ingénieur.

1. Tout ingénieur doit s'associer aux efforts de ses collègues en participant à toutes les activités volontaires, professionelles et techniques du groupement auquel il a choisi d'appartenir. J'espère que c'est l'Institut canadien des ingénieurs.
2. Tout ingénieur doit avoir à coeur de transmettre à la communauté à laquelle il appartient les conseils réfléchis et impartiaux que son expérience particulière a pu lui inspirer.
3. Tout ingénieur se doit de participer aux délibérations collectives de son milieu et d'y occuper le rang pour lequel sa formation professionnelle le qualifie si bien.
4. Tout ingénieur doit être conscient de ses responsabilités envers la communauté canadienne, en faisant fructifier l'héritage de connaissances techniques que lui ont transmis ses devanciers.
5. Tout ingénieur doit contribuer autant qu'il le pourra à une meilleure compréhension des problèmes de nos semblables vivant dans les pays sous-développés, tout en les aidant à s'aider eux-mêmes.

JE SUIS CONVAINCU que si nous, ingénieurs canadiens, nous nous attelons à la tâche que je veins de résumer, les 75 prochaines années de notre Institut seront belles et dignes de l'héritage que nous avons reçue. A nous d'être à la hauteur de l'avenir qui s'annonce.

POUR MA PART, en toute humilité, j'accepte l'honneur que vous me faites en m'élevant à ce poste que tant d'éminents ingénieurs canadiens ont occupé avant moi. A titre de président, j'espère pouvoir contribuer, au moins dans une modeste mesure, aux très grands services que notre pays et nos semblables sont en droit d'attendre de l'Institut canadien des ingénieurs.

F. L. Lawton, M.E.I.C.
Président, 1962-1963.

News of the Branches

Amherst

G. C. L. MeEnery, M.E.I.C.
Correspondent

The Branch's meeting at the Fort Cumberland Hotel April 13 was oriented towards the interests of senior engineering students at Mount Allison University. W. D. Hagan, Chairman of the Branch, introduced Dr. Henry Hicks, Vice-President and Dean of Arts and Science at Dalhousie University, who addressed the students on the many opportunities available to graduate engineers in the business world of today. Dr. Hicks suggested that since engineers are being asked to move into the fields of management and administration, engineering students need more than the technical knowledge they receive in their undergraduate course. In these fields, the graduate engineer may find himself ill-equipped to cope with the problems which may arise. He urged students to take extra courses and to do extra reading to prepare themselves for any added responsibilities. Dr. Hicks was thanked by R. D. McInnis, President of the Engineering Society at Mount Allison University.

Special guests at this meeting included Dr. F. L. West, Vice-President of Mount Allison University and M. T. Avard of Amherst.

Belleville

A. F. G. Tooth, M.E.I.C.
Correspondent

On March 12, the Branch held a dinner meeting at the Shrine Club. E. A. Cross, Ontario Regional Vice-President of the Engineering Institute of Canada, and Col. T. M. Medland, Executive Director of the Ontario Association of Professional Engineers were the guest speakers. W. N. Throop introduced both guests who spoke on Confederation.

Mr. Cross traced the growth of the Institute from its formation in 1887, when it was known as the Canadian Society of Civil Engineers, through to 1918 when it became the Engineering Institute of Canada encompassing all fields of engineering.

The Confederation Commission was organized to study the proposed unification of the Institute and the provincial associations, and to present a report. This report is now being studied by the Institute and the provincial associations. Evidently, there are several problems to be settled before Confederation is acceptable to both engineering bodies. Col. Medland confirmed the problems mentioned by Mr. Cross. Both speakers were thanked by J. A. Grant for their talks on a subject which is of importance to all engineers.

Border Cities

William J. Lueiani,
Correspondent

The Branch held its second annual students "paper night" March 12 in the new Essex College auditorium. The students were chosen by members of the university faculty. The talks were based on thesis worked on during the year. Cash prizes were awarded to Wesley M. Brigden, who spoke on "Microwave Amplification by the Stimulation Emission of Radiation"; Paul S. Dunseath, "The Photovoltie Effect — Its Efficiency and Uses"; David J. Peach, "Pumped Storage Plant to Handle Power at Peak Loads" and Michael W. Prince, "Model Analysis of Structures".

In addition, an Engineering Institute of Canada proficiency award and prize were presented to Gary S. Dunlop, a 1961 engineering graduate from Windsor. The award is presented annually to a student for his competition in engineering courses and his work with engineering societies.

Harris Chapman, M.E.I.C. Engineering Consultant in Windsor was the guest speaker at the Branch's April 12 meeting. The title of his talk was "The Engineer and the Price System". This was essentially a talk on applied economics, dealing with the effect of the economy on engineers, and the engineers' effect on economy. Mr. Chapman gave an accounting calculation of the value of an engineer to the economy. This was demonstrated by the use of a chart showing Canada's economic figures and its industrial ownership over the past few years.

Brockville

A. N. Campbell, M.E.I.C.
Correspondent

A. G. Stewart, Manager, Industrial Products Division, Automatic Electric Sales (Canada) Limited, Brockville, Ont., was the guest speaker at the Branch's March 6 meeting. The title of his talk was "Visual Communications", in which he reviewed briefly the history of both visual and audible communications, and television. The validity of the use of television as an entertainment medium was questioned and examination was made of the potential that television holds as a means of visual communication in commerce, industry and education. There is a large group of people now bent on exploiting closed circuit television to the fullest extent in the fields mentioned. The problems of cost, complexity and reliability which arose in the early days of closed circuit television have now been overcome.

Mr. Stewart supplemented his talk with color slides showing various types of the latest in television equipment and some of the most reeent installations and uses of typical direct wire television equipment. A closed circuit television installation was set up and a demonstration was presented. The display illustrated vividly that direct wire television can play an extremely important part in most fields including those of commerce, industry and education. Mr. Stewart was thanked by D. B. Ashenden.

Cape Breton

Lloyd Boutilier, M.E.I.C.
Correspondent

The Branch held a meeting on March 1 at which Capt. E. S. Brand, Director, Marine Operations, Ottawa, was the guest speaker. He spoke on Ice Breaking Operations, and said that ice breaking operations are necessary because throughout the last four years, several large industries in the Seven Islands, Port Cartier, and south shore areas have decided to operate 12 months per year. Such areas require trade and supplies to maintain their economies and continue their growth. The Federal Government was forced to meet this problem and supplied ice-breakers to keep the shipping lanes open throughout the winter.

(Continued on page 148)

Library Notes

Prepared by the Library, The Engineering Institute of Canada

Book notes marked by an asterisk have been provided through the courtesy of The Engineering Societies Library in New York.

BOOK REVIEW

*INTRODUCTION TO PHYSICAL GEOLOGY, 2ND ED.

In this revision little change has been made in the general order of treating major subjects, but most parts of the text have been reorganized, rewritten, and considerably amplified to make the presentation clearer and more up-to-date. Many diagrams and half-tones have been replaced, and the total space given to illustrations increased by more than fifty percent. An innovation is the inclusion of precise definitions of geologic terms within the pages of the text devoted to subject matter with which the terms are concerned. A brief summary at the end of each chapter has also been added. (C. R. Longwell and R. F. Flint. New York, Wiley, 1962. 504p., $7.95.)

*VECTOR MECHANICS FOR ENGINEERS, PART I: STATICS.

The foundations of formal vector methods are presented in an orderly manner, to increase the engineering student's understanding of elementary mechanics and to establish a framework for more advanced analysis. The editor and the four other contributors are all on the staff of Case Institute of Technology. (H. R. Nara. New York, Wiley, 1962. 455p., $6.50.)

*NUMERICAL METHODS IN ENGINEERING, 2ND. ED.

This second edition preserves the essential structure of the original work, while at the same time extending its scope through numerous additions and extended treatment of certain of the original topics. The author covers the practical solution of algebraic and transcendental equations, finite differences and their applications, the numerical integration of initial value problems, the numerical integration of ordinary boundary value problems, and the numerical solution of partial differential equations. Written from the engineer's point of view, this work is applicable to all fields of engineering and applied science. (M. G. Salvadori and M. L. Baron. Englewood Cliffs, Prentice-Hall, 1961. 302p., $10.65.)

*ANALYSIS OF BISTABLE MULTIVIBRATOR OPERATION.

An extended analysis of the transient behavior of the bistable multivibrator circuit. This edition has been enlarged by an extra chapter which contains some actual bistable multivibrator circuits and binary or decimal counters composed of such circuits. (P. A. Neeteson. New York, Rider, 1961. 92p., $2.90.)

*AUTOMATIC CONTROL SYSTEMS

A comprehensive treatment of the principles and techniques utilized in the analysis and design of feedback control systems. Starting with a review of the mathematical background of control systems, the theory of feedback is developed from a general point of view. Techniques discussed are frequency domain (using Nyquist criterion, Bode plot, and Nichols chart), root locus, and root contour. The book is so prepared that it can be used for either a first or an intermediate course in servomechanisms. A knowledge of basic circuit theory is assumed. (B. C. Kuo. Englewood Cliffs, Prentice-Hall, 1962. 504p., $16.00.)

*A WRITER'S GUIDE FOR ENGINEERS AND SCIENTISTS.

Using a practical approach, this guide first analyzes the common problems of writing in any technical field, and then presents positive method for dealing with them.

Examples of effective writing are given for both general and specific presentations, taken from published reports and articles. (R. R. Rathbone and J. B. Stone. Englewood Cliffs, Prentice-Hall, 1962. 348p., $7.95.)

THE ENGINEERING INSTITUTE LIBRARY

The publications mentioned in these notes are now available in the Library, and may be borrowed by members of the Institute. Two items may be borrowed at one time for a period of two weeks, excluding time in transit.

Library hours are: Monday to Friday: 9 a.m. to 5 p.m. All requests and enquiries should be addressed to the Librarian at 2050 Mansfield Street, Montreal.

*DESIGN OF MACHINE ELEMENTS, 3RD. ED.

In this edition the author has simplified and streamlined analytical techniques used for the design of the various machine elements. He first covers theories of mechanics and strength of materials, proceeding on to stress concentration and repeated loading. He then discusses in detail such basic machine members as shafts, springs, screws, bearings, gears, cams, and press fits. The concluding chapters cover correct dimensioning and detailing, and metallurgical properties of engineering materials. (M. F. Spotts. Englewood Cliffs, N. J., Prentice-Hall, 1961. 583p., $13.35.)

*SYMPOSIUM ON FIRE TEST METHODS.

Information on the techniques and evaluation of fire tests is presented in this volume. The papers included deal with pioneer attempts to simulate actual conditions in a burning structure, prediction of fire test results, a new beam furnace, and a survey of test methods and comparison of results when measuring surface flammability of materials. (Philadelphia, American Society For Testing and Materials. 1961. 82p., $3.25. s.t.p. no. 301).

*THE SCIENCE OF DAYLIGHT.

From the diversified literature of physics, architecture, photo-biology, color, and law, the author has attempted to draw together an ordered account of research on daylight. Of particular interest to engineers are the chapters on the design of windows, daylight requirements for buildings, daylight calculation by graphical and non-graphical methods, and sunlight control. There is also a chapter on the legal protection of daylight. (J. W. T. Walsh. London, Macdonald, 1961. 285p., £2.)

*METALLURGY IN THE SERVICE OF MAN.

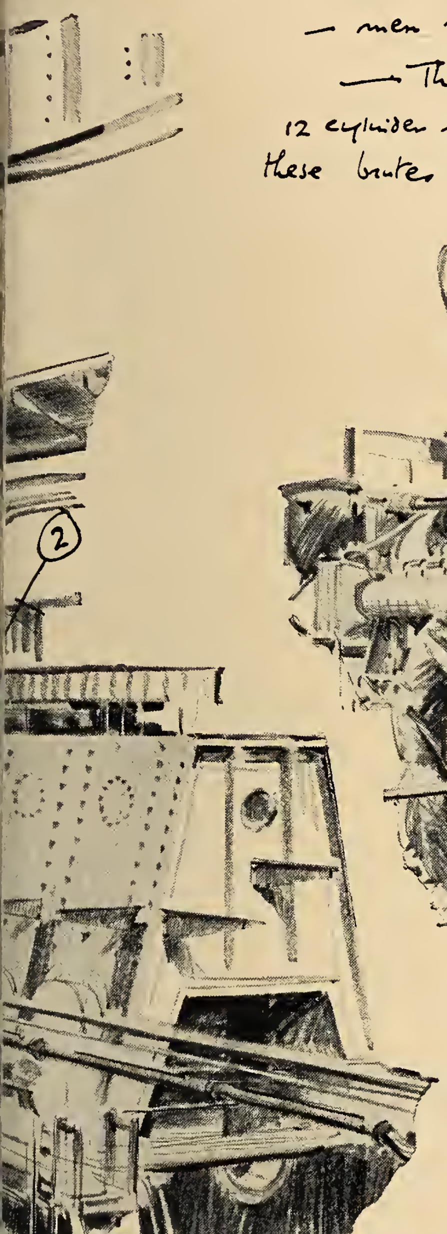
The field of metallurgy is reviewed both in its general principles and in its industrial application. Individual chapters discuss mineral dressing; extractive metallurgy; production of iron and steel; cast iron and ferro-alloys; mechanical properties and shaping of metals; non-ferrous metals; light-weight metals; uranium; and minor, precious, and rare metals. (W. H. Dennis. London, Macdonald, 1961. 372p., 45/—.)

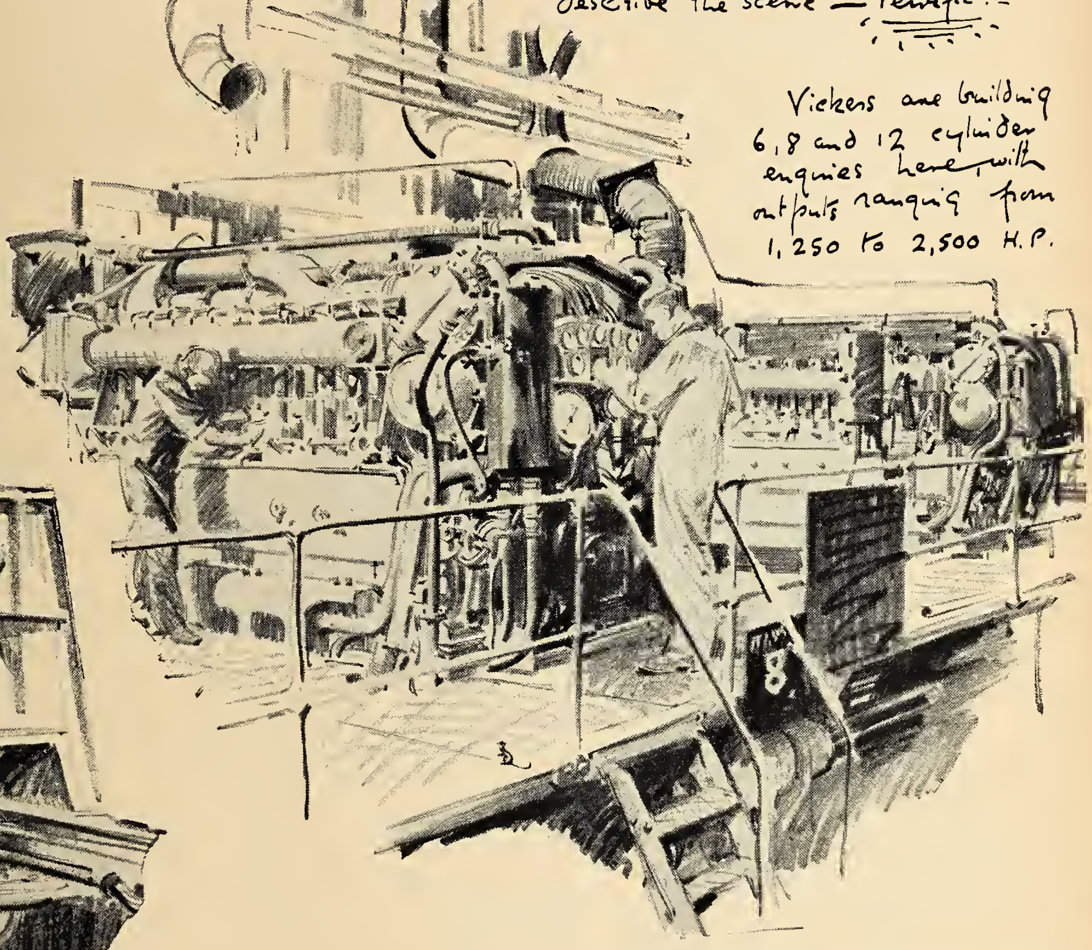
(Continued on page 128)

OF ITS TYPE. VICKERS-SULZER ENGINE IN THE ERECTION PITS.

scaffolding shrouded monster will be in a ship, one day. It is the first of its type built at Barrow. The second being on the bed alongside. (Marked 2)

A row of engines — roaring; rocker arms dancing like notes on a crazy pianola — all around, the pulsing beat of power, steady & insistent — men moving about, calm, watching the dials, checking, adjusting — This is the SULZER TEST BED. These engines are LDA. 12 cylinder jobs, for BRITISH RAILWAYS. I've had to squeeze past many of these brutes whilst riding on locomotives, but this is my first experience of static diesels under a full throttle! I can describe the scene — terrific!





Vickers are building 6, 8 and 12 cylinder engines here, with outputs ranging from 1,250 to 2,500 H.P.

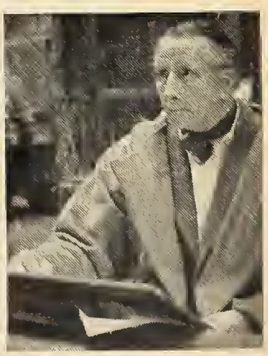
STATISTICS:

8RD76, two stroke Supercharged engine, for ELLERMAN LINE.
Eight cylinders. 760 m/m bore ×
1,550 m/m stroke
10,300 brake H.P. at 119 R.P.M.
480 tons in weight.

Cuneo

able

Here are more sketches drawn by Terence Cuneo at the Barrow Works of Vickers-Armstrongs (Engineers) Ltd. Both drawings feature transport propulsion, one of the activities of the Vickers Group of Companies that has received mention before in this series. The drawing of the marine engine gives some idea of the size of job undertaken at Barrow Works. Starting in 1872 these Works of the Engineering Company now cover 88 acres and employ about 8000 people exclusive of the Ship-building Company Works which cover a further 61 acres and employ an additional 4500 people at Barrow.



• Library Notes

(Continued from page 124)

*MECHANICAL PROPERTIES OF ENGINEERING CERAMICS.

A collection of papers presented at a conference held at North Carolina State College in 1960. The papers are divided into five sections which deal with imperfections and deformation processes, thermal stress and mechanical properties, the mechanical properties of oxide ceramics, the mechanical properties of graphite, and the mechanical properties of non-oxide ceramics. While attention is concentrated to some degree on refractory, non-metallic, and crystalline solids, this volume also presents research on related materials including alkali halides, brittle alloys and semi-conductors, unusual glasses, and composites. (Ed. by W. W. Kriegel and Hayne Palmour. New York, Interscience, 1961. 646p., $21.00.)

*INTRODUCTION TO SPACE DYNAMICS.

Intended for the intermediate or graduate level of instruction this text begins with essentials of vector algebra and kinematics through the general case of space motion in moving coordinates. It goes on to discuss such topics as: coordinates for space motion and orbits in a central force field; gyrodynamics and gyroscopic theory as applied to instruments, missiles, and satellites; the attitude of spinning rockets, missiles, and satellites; optimization of multistage rockets, trajectories, and orbit transfer problems; and the generalized theory of dynamics. (W. T. Thomson. New York, Wiley, 1961. 317p., $11.50.)

*STABILITY BY LIAPUNOV'S DIRECT METHOD WITH APPLICATIONS.

A detailed and elementary account of Liapunov's second method. This is the only general method now available for the study of stability of nonlinear systems and has both practical and theoretical applications. Certain mathematical essentials are reviewed at outset and are followed by numerous examples illustrating applications of the method. (Joseph La Salle and Solomon Lefschetz. New York, Academic, 1961. 134p., $5.50.)

*MANAGEMENT MODELS AND INDUSTRIAL APPLICATIONS OF LINEAR PROGRAMMING. VOLUME 2.

The present volume complements the introductory material of volume 1 through "model types" which have been derived from actual experience. Transportation type, incidence type, coupled and dyadic models are presented, as well as subdual and double-reverse methods. A section is devoted to an oil pipeline model, and some extensions of game theory are presented. A lengthy bibliography is included. (A. Charnes and W. W. Cooper. New York, Wiley, 1961. p. 469-859, $11.75.)

*METHODS ENGINEERING: DESIGN & MEASUREMENT OF WORK METHODS.

The author presents principles and practice with a critical evaluation of methods. He applies the work of psychologists and engineers to methods design and presents new means of rating work measurement. Unbalance and variation in production capabilities are discussed, and finally the administration of personnel and performance in the methods engineering function is evaluated. The appendices contain some individual methods and tables. (E. V. Krick. New York, Wiley, 1962. 530p., $10.75.)

"A Report on the Education and Training of Professional Engineers in the United States", published by the Engineers' Council for Professional Development is available to members of the Engineering Institute of Canada at $3.25 per copy. Further information may be obtained by writing to: Elsie Murray, Executive Secretary, Engineers' Council for Professional Development, 345 East Forty-Seventh Street, New York 17, N.Y.

*MOMENT DISTRIBUTION.

This method of analysis for rigid-jointed structures is intended to be a continuation of Continuous Frames in Reinforced Concrete, by Cross and Morgan, with the addition of some new design procedures. The elastic method for either prismatic or haunched rectilinear and inclined members, curved members, and circular tanks are discussed. The applications of moment distribution to allow for shearing and axial forces, elastic beam-column connections, and elastic instability are also presented. (Edgar Lightfoot. London, Spon, 1961. 363p., 67/6.)

*THE INFLUENCE OF TEMPERATURE ON THE MECHANICAL PROPERTIES OF METALS & ALLOYS.

In this translated Russian treatise the author examines mechanical properties and their relation to the internal structure of solids, mechanisms of plastic deformation, and general physiochemical relations. He discusses the influence of temperature on the mechanical properties of monomorphic and polymorphic metals, metallic compounds, and alloys in eutectic and solid-solution systems. Lastly, criteria are given for selecting optimum conditions for hot-working alloys. (E. M. Savitsky. Stanford, University Press, 1961. 303p., $9.00.)

*SCIENTIFIC FOUNDATIONS OF VACUUM TECHNIQUE, 2ND. ED.

The basic science of all the operations of the production and measurement of high and ultra-high vacuum is incorporated in this volume together with practical technology. The production, measurement, and utilization of vacua are related to fundamental concepts of kinetics and sorption. The staff of General Electric Research Laboratory has enlarged the 1949 edition and has added new material to the text and the references. (Saul Dushman. New York, Wiley, 1962. 806p., $19.50.)

(Continued on page 177)

1962 CONFERENCES

OF PARTICULAR INTEREST TO E. I. C. MEMBERS

Following is a tentative list of conferences to be held later this year either totally or partially under the sponsorship of the Institute. Further details will be carried on a regular basis in the pages of the Engineering Journal.

August 24 - 25	**Baie Comeau Regional Conference**
September 12 - 14	**Edmonton Conference**
September 13 - 14	**Soil Mechanics Conference, Edmonton** **JOINT NRC - EIC**
October	**Chemical Engineering Conference, Sarnia** **JOINT CIC - EIC**
Autumn	**Newfoundland Regional Conference**

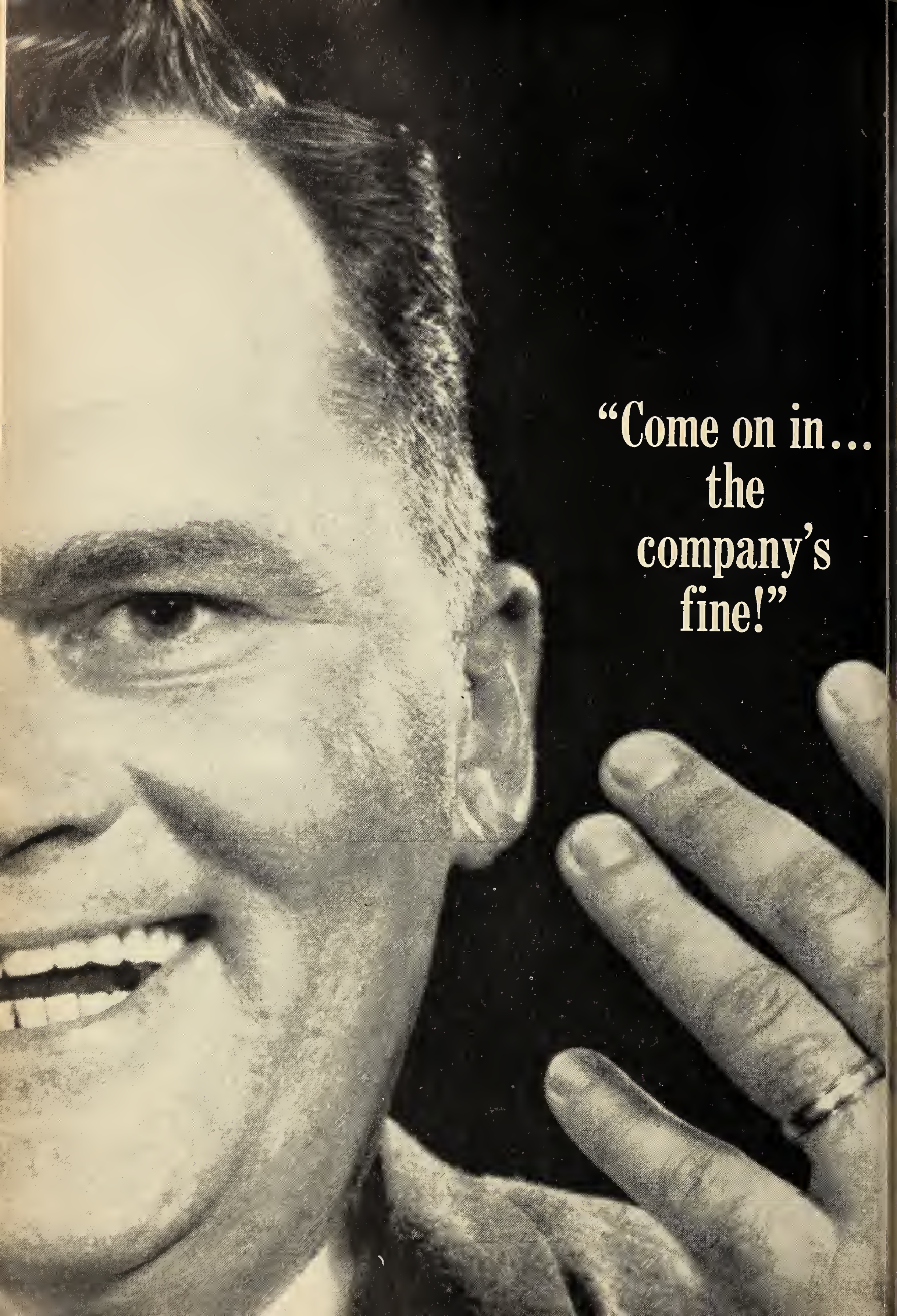
Obituaries

(Continued from page 116)

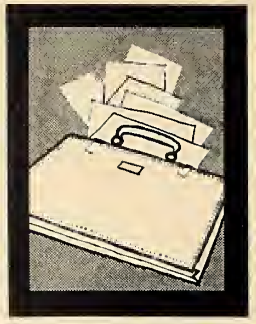
Mrs. Frederick Perry Shearwood died April 18, 1962, in Montreal. She was 94. Mrs. Shearwood was one of the earliest women students to attend McGill University from which she graduated in 1890. After graduation, she worked for the Canadian Society of Civil Engineers which in 1918 became the Engineering Institute of Canada. She was married in 1898 to the late F. P. Shearwood, and was active in church and charitable work including the Women's Auxiliary of Christ Church Cathedral, and the Alumnae Society of McGill University. In later years she was interested in the Canadian Authors Association and had published three books on Canadian subjects including, By Word and Water, and had contributed many articles to periodicals. Her husband died in 1956. Surviving are one son, A. P. Shearwood, a daughter, Mrs. C. F. Furse, and four grandchildren.

H. R. Younger, LIFE M.E.I.C. died September 18, 1961. Mr. Younger graduated from McGill University in 1910 with a Bachelor of Science Degree in Civil Engineering. He became an Associate Member of the Engineering Institute in 1913, a full member in 1940, and a Life Member in 1948.

Hew Martin Scott, LIFE M.E.I.C. died early this year. He became a Life Member of the Engineering Institute of Canada in 1955, and had been a member of the Institute since 1920.


"Come on in...
the
company's
fine!"

Business and Industrial Briefs



Appointments and Transfers

Joseph Black has been appointed Manager of the Tanker Division of Truck Engineering Limited, Woodstock, Ont. Mr. Black has served for more than 26 years in the design engineering, production and sales of tanker units. Initially, Mr. Black will be located at the company's headquarters in Woodstock. He will later be transferred to the Toronto office at Rexdale.

John L. McGavin has been appointed Manager of the Windsor branch of Burroughs Business Machines Ltd. Mr. McGavin joined Burroughs in 1948 as a sales representative in Winnipeg where he remained until 1953, when he was transferred to Toronto as a regional sales promotion representative. In 1957, he returned to Winnipeg as a zone sales manager.

Jean Paul Gagnon has been appointed Canadian Sales Manager of Eutectic Welding Alloys Corp. Mr. Gagnon joined the company in 1953 and has since been Technical Representative, Field Supervisor and Regional Manager. He will make his headquarters in Montreal.

Roy G. Peers has been elected Director of ACF Industries (Canada) Limited. Mr. Peers also is a director of Boeing of Canada, Ltd., Catalytic Construction of Canada, Ltd., and Milltronics, Ltd.

Reginald L. Johnson has been appointed director of advertising and public relations for the Johns-Manville Corporation, Port Credit, Ont.

John D. Leitch, Chairman, Maple Leaf Mills Ltd.; **Edwin A. Locke, Jr.,** President, Union Tank Car Company; **W. Harvey Cruickshank,** Vice-President and General Manager, Toronto Area, Bell Telephone Company of Canada; **Ronald M. Melvin,** Managing Director, Procor Limited; **M. O. Simpson, Jr.,** President, Combined Enterprises Limited; and **J. W. Van Gorkom,** Executive Vice-President, Union Tank Car Company, have been appointed as Directors of Procor Limited, Toronto.

E. A. Planche of the chemicals division of Canadian Industries Limited, has been appointed works manager of the new C-I-L chlorine and caustic soda plant at Dalhousie, N.B. Mr. Planche has held various positions in the company's chemicals division, and most recently was production superintendent, Hamilton works.

Jean Gilles Caron has been appointed zone sales manager in the Montreal Branch of Burroughs Business Machines Ltd. Mr. Caron joined Burroughs in 1940, and has since held sales positions in Montreal and Sherbrooke.

E. J. Standtlander has been appointed Purchasing Manager at the Canadian Blower and Forge Co. Ltd. Mr. Standtlander joined the engineering department of the company in 1940, and was appointed Production Manager in 1943.

Albert Lalande has been appointed manager, education services at the Montreal Branch of Burroughs Business Machines Ltd. Mr. Lalande joined the company in 1940, and in 1954, became a zone sales manager. Mr. Lalande graduated from the University of Montreal and holds a Masters degree in commerce.

John D. Lynch has been appointed the New Construction Specialist in the Toronto area for the Tremco Manufacturing Company (Canada) Limited. He will provide a technical service to architects, engineers, contractors and builders.

N. H. Hollefriend has been named Manager of Marketing for Canadian Allis-Chalmers Limited. Mr. Hollefriend has had 30 years of experience with the company, and a combined knowledge of products, sales and application engineering.

Roger Chartier, Professor of Industrial Relations at Laval University, has been named General Manager, Personnel, at Quebec Hydro-Electric Commission. Mr. Chartier was formerly Assistant to the Director of Personnel, at Rio de Janeiro Light.

Bruce W. Darling has been appointed Manager of Canadian Field Sales for Garrett Manufacturing Limited. Mr. Darling has been a Garrett representative in Ottawa for several years and will maintain his headquarters there.

C. L. Echlin has been appointed manager, sales and service of Canadian Allis-Chalmers Limited. Mr. Echlin has more than 30 years of experience in the company's sales, field service and erection work.

Developments

Information contained in this section has been obtained from press releases. Mention of products and services does not imply endorsement by the Institute.

MAJOR EXPANSION of the Terrebonne, Que. plant of the Matthew Moody Division of Canadian Bowl-Mor Co. Ltd., has begun and will eventually make the company one of the largest Canadian manufacturers of manual materials handling equipment. The new plant will increase manufacturing and storage area by one third. New machinery to be installed will include a 150-ton press brake. The company will manufacture for FICO "Backbone" pallet racking and "Bowl-Mor" automatic pinsetting equipment for the bowling industry.

TWO MINIATURE ELECTRONIC controllers, fully transistorized and self-contained, have been announced by Thermovolt Ltd. Type PEC measures 7½ inches by 3¾ inches; type MEC, 6 inches by 3 inches. Both have full ambient compensation and thermocouple break protection. Both are available with cross coil elements for resistance thermometers or any other application where the process measurement can be converted into direct current and voltage.

(Continued on page 168)

(Continued from page 122)

In his talk Capt. Brand discussed the use of helicopters to find "blue sea", how an ice-breaker frees an ice-locked ship. He said that information as to which ships were entering certain areas was obtained through shipping agents at least 36 hours before the arrival of these ships. Capt· Brand then described how a number of ships were corralled into one area so that one ice-breaker could operate more efficiently. He explained how information was obtained from the meteorological centres in the area of approaching ships. He described other marine operations such as search and rescue, supply to northern ports and weather ports off the coast of British Columbia. The talk was followed by slides of the ice-breakers, northern ports and DEW line bases.

Corner Brook

Robert G. Scott, M.E.I.C.
Correspondent

M. J. Howley, City Engineer, City of Corner Brook, was the guest speaker at the March 27 meeting of the Branch, where he gave a brief outline of the Municipal plan for the City of Corner Brook. Mr. Howley first explained municipal plans in general, describing how these came into being, their legal status and their effect on the community and its individual citizens. He then referred to several maps and drawings and explained the varied aspects of each. He also explained how the city administration proposed to carry out these municipal plans. The question and answer period which followed Mr. Howley's talk proved to be one of the most lively of the year.

R. Newton, M.E.I.C., on the request of the Chairman, gave a brief chronological resume on Confederation.

The Branch plans to hold its annual meeting and election of officers on May 22. This will include a dinner and dance for the members and their wives.

Cornwall

F. R. Warner, M.E.I.C.
Correspondent

Harold W. Blakely, President of Crane Canada Ltd., was the guest speaker at the Branch's March meeting. Mr. Blakely outlined the role of the engineer in top management positions. He said that the engineer, through his training, is best suited to fill top management posts. He stressed the need for more adequate training. He said the engineers' scientific training should be increased but not at the cost of reducing humanities training. Mr. Blakely advocated a five-year course for an engineer to achieve the aims he outlined.

Mr. Blakely touched on the economic problem, saying that the Canadian economy should be better organized than it is today. He said there is too much provincialism in the Canadian economy, and that Canada will soon have to choose sides in the world trading bloc.

Mr. Blakely was thanked by C. I. Bacon.

:dmonton

:. J. Allman, M.E.I.C.

:orrespondent

The Branch held a meeting March 8, at the Seven Seas Restaurant. The peaker of the evening was J. E.)berholtzer, Deputy Minister of Indus- ry and Development for the Govern- ıent of Alberta. Mr. Oberholtzer's topic :as "The Alberta Industrial Picture- 'ast and Future". He spoke at length n Alberta's industrial growth, and dealt vith the many changes that have taken ılace in industry in Alberta since 1900. \t the turn of the century, the natural esources of Alberta were virtually un- mown and untouched. Industrial growth mproved steadily and the turning point n Alberta's industrial picture was on 'ebruary 13, 1947. On that date, a new ra in natural resources started when Leduc Number 1 oil well became a pro- lucer and ushered in the vast oil, and ;as industry. Mushrooming oil wells soon orought about the building of pipeline ınd refineries and by 1955, the total re- fining capacity had almost reached 30,000 barrels per day.

Mr. Oberholtzer predicted that there would be a steady increase in the pro- duction of oil and gas in the Province during the next 40 to 50 years, and said that although the natural resources had been developed rapidly, up to the pre- sent time, conservation of these resources had been part of this development. He stated as a result of this conservation, the natural resources of the Province would be adequate for many future decades.

Halifax

D. E. Rudolph, M.E.I.C.

Correspondent

The Branch held a dinner meeting on April 3 at the Flamingo Restaurant which 71 members attended. The speaker for the evening was A. R. Harrington, Vice-President and General Manager of Nova Scotia Light and Power Company Limited. Mr. Harrington spoke on productivity, a subject in which he is vitally interested as he is a member of the National Productivity Council, representing the Atlantic Provinces, and is also Chairman of the Nova Scotia Productivity Committee.

Productivity has been described as the "ability to supply goods and services needed by the community with the minimum consumption of real resources". In other words, it is a ratio of input to output and, as such, is not the same as total production. The part engineers have to play with the increase in productivity must not be minimized, and as Canada becomes more industrialized, the engineers' part in this important aspect of our economy increases. When designing, proper thought must be given to the raw materials, men and management. Canada's production level, when compared with that of other countries, is very low. If we wish to maintain our standard of living and raise it, we must raise the level of production per person

(Continued on page 164)

Employment Service

THE ENGINEERING INSTITUTE OF CANADA

This service is operated for the benefit of members of the Engineering Institute of Canada and for organizations employing engineers.

SITUATIONS WANTED

Advertisements are inserted free of charge for members of all classes. Maximum length is 60 words, and repeat insertions must be separately requested in writing for each desired appearance.

SITUATIONS VACANT

Rate: Six dollars per column-half-inch per insertion.

Replies to advertisements should be addressed to the file number, Employment Service, 2050 Mansfield Street, Montreal. Interviews with the Employment Service may be arranged by calling VI 2-8121 at the above address.

SITUATIONS WANTED

MARINE ELECTRICAL ENGINEER — M.E.I.C., Grad. I.E.E., H.N.C., age 35, married. Fully qualified with Canadian and U.K. experience in electrical installations on all new ship construction, refit, repair and associated shipyard plant; in all phases of supervising, estimating, drafting and electrician labour. Presently employed as Manager. Desires similar position or Chief Draftsman. Would consider any location. File No. 257-E.

CIVIL ENGINEER, M.E.I.C., P.Eng. Age 34, married. 6½ years experience in bridge work involving the construction of timber, concrete and steel bridges. One year varied experience in general contracting work and public works. Prepared to locate anywhere. Available on two weeks notice to present employer. File No. 256-C.

ENGINEER-ACCOUNTANT, M.E.I.C., P.-Eng. (Ont.), A.M.I.Mech.E., R.I.A. (Intermediate). Age 37. Experience in chemical and mechanical design, maintenance, construction and administration. Also plant methods, budgetary control, material procurement and inventory control. A profit-oriented executive seeking a company who will benefit from these talents and who can offer further opportunity after proof of performance. File No. 255-M.

MECHANICAL ENGINEER, M.E.I.C., P.-Eng. (Ont.), B.Sc. Queen's 1952, age 41. Experience — six years maintenance engineer, petro-chemical and pulp & paper industry; one year as plant engineer; two and one half years in design on plant engineering. Desires position in field of design, plant engineering or maintenance. Resume available. Prefer Ontario or Montreal. File No. 254-M.

ELECTRICAL ENGINEER, M.E.I.C., P.-Eng. (Ont.), married, age 43. Experience in electronics, hydro-electrical systems construction, maintenance, design and transmission in nearly all phases, including supervisory positions. Considerable experience in research and consulting on electrical conductors and fittings, including aluminum. File No. 6474-E.

MECHANICAL ENGINEER, A.M.E.I.C., B.A.Sc. (Toronto 1960), Graduate of R.M.C., age 24, married, serving in Royal Canadian Navy. Three years' experience in man management and general administration. Desires interesting engineering position. Any location considered. Available February 1963. File No. 253-M.

CONSTRUCTION ENGINEER, B.Eng. (Civil) McGill 1953, age 31, single. Considerable experience in field supervision and inspection of military building projects and industrial buildings. Thoroughly familiar with office routine, estimating, preparing and checking plans and specifications. File No. 252-C.

CHEMICAL ENGINEER, B.E. (SASK. 1959), A.M.E.I.C., P.Eng., married, age 24, with two years' experience in analytical and animal feeds technology. Desires position in testing and analysis or research and development. Location — Edmonton, Alberta. Available immediately. File No. 251-Ch.

RETIRED EXECUTIVE, M.E.I.C., P.Eng. (Que.), desires position, either full or part time, where past diversified experience can be an asset. Broad experience in Administration, Management, Labor and Production; also qualified Mechanical and Civil Engineer. Well versed in all phases of construction; maintenance; cost reduction; purchasing; contracts; studies and reports, etc. In excellent health. Do not want to stagnate. Willing to travel. File No. 250-M.

MECHANICAL ENGINEER, A.M.E.I.C., age 30, (N.S.T.C. '59), married with 2 children. Three years plant engineering and maintenance experience in quarrying operation. Desires to try new phases of engineering in mechanical industry. Maritimes preferred, but will relocate. File No. 249-M.

CIVIL ENGINEER, S.E.I.C., B.E. 1962 University of Saskatchewan. Seeks position related to structures or road construction. Plenty of surveying experience. Some construction and some design experience. Resume on request. Will consider position anywhere in Canada. File No. 248-C.

MECHANICAL ENGINEER. M.E.I.C., P.-Eng., A.M.I.Mech.E., M.I. Nuclear E., age 40, with wide experience in maintenance of plant and equipment, also plate fabrications in medium and light engineering fields, seeks progressive position in administrative capacity where hard work, integrity and record of success in this field can be utilised for mutual benefit. Location preferred Ontario or West. File No. 170-M.

CHEMICAL ENGINEER — Bilingual, with experience in pulp and paper industry, sewage treatment equipment, seeks position in control, research, development or production departments in pulp and paper industry or allied fields. File No. 187-Ch.

ELECTRICAL ENGINEER, P. Eng., A.I.-E.E., E.I.C., 7 years experience in various fields. Seeks employment with a consulting or manufacturing firm. File No. 6405-E.

CIVIL ENGINEER, age 36. Graduate 1952, Delft, The Netherlands. P. Eng., Ontario. 2 years field experience and 8 years diversified experience in structural engineering for industrial projects and hydraulic structures; also preliminary layouts and reports for hydro-electric and flood control projects. Desires challenging position with growth potential in consultant office or with contracting firm. File No. 247-C.

CIVIL ENGINEER — B.Sc., A.M.I.C.E., M.E.I.C., P. Eng., age 41. Broad experience, 8 years field supervision, 6 years estimating, 4 years consulting, 3 years industry, covering studies, reports, liaison, design, supervision, management, planning, estimating, negotiation, etc. Seeks permanent position. Consider any location but prefer Toronto. Available immediately. File No. 246-C.

EXPLORATION MINING ENGINEER, B.Sc., P. Eng., 15 years exploration and production experience, presently employed as exploration supervisor, desires similar position with a more active company. Presently located northwestern Ontario with good office facilities. File No. 245-Min.

ENGINEER-ECONOMIST, P. Eng. (Civil) McGill 57. Canadian. Diploma in Management and Business Administration as well as additional training in economics, advanced mathematics, statistics. Experienced in various phases of structural steel and reinforced concrete design. Has been in charge of multi-million dollar erection projects. Planning, market analyses, economic appraisals, costing, contract negotiation and general administration. Energy requirements and future development of petroleum industry. Seeks position where technical, managerial, administrative and social aspects are of an asset. File No. 6482-C.

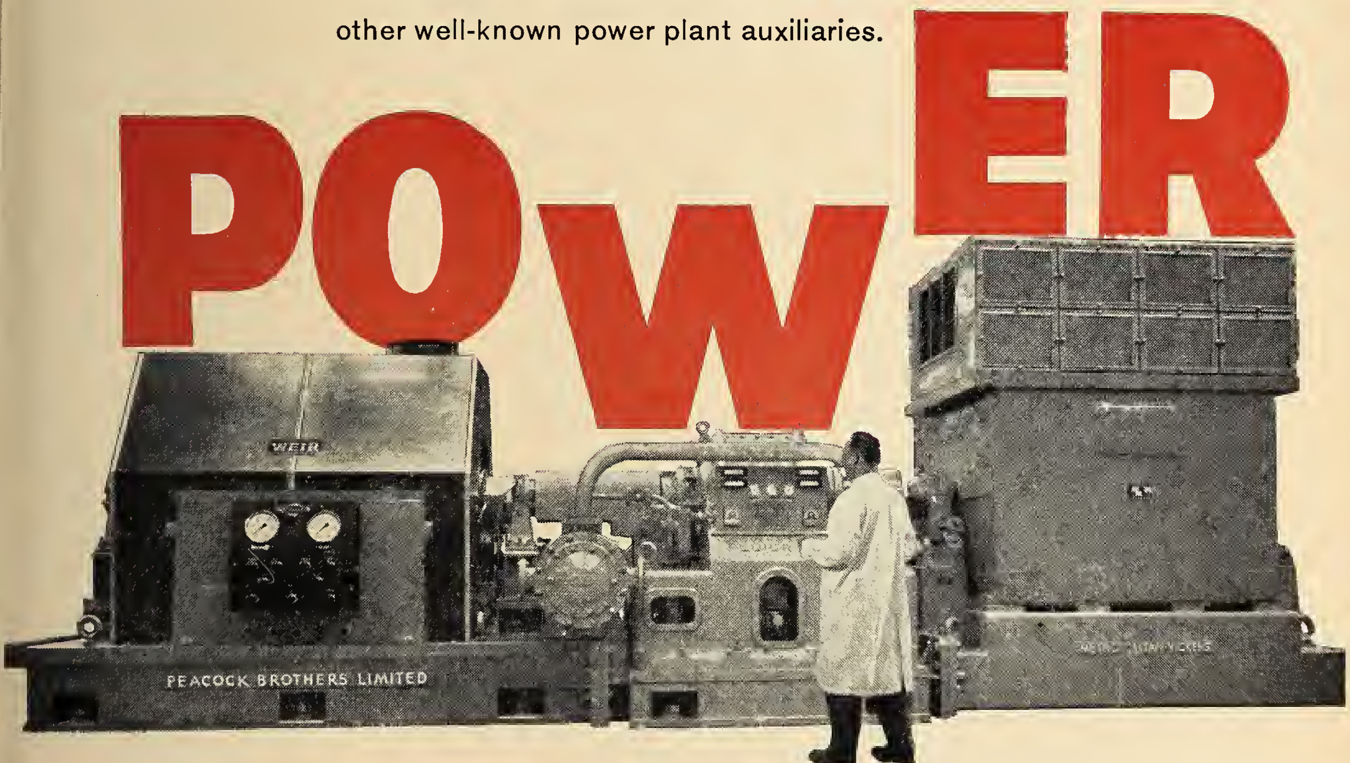
PLANT MANAGER, M.E.I.C., P.Eng., Age 39, married. Holder of engineering and business degrees. Diversified experience in production and scheduling, contracts administration and negotiations, plant layout and maintenance, budgeting, industrial engineering and management problems, wage and labor analysis, field projects supervision and co-ordination. Desires responsible position preferably in mechanical industry, would consider small capital investment. Location Montreal. File No. 6498-W.

ELECTRICAL ENGINEER — M.E.I.C., graduated in Electrical Engineering from London in 1956. Age 31 years, married, widely travelled, immigrant in Canada. Having 4 years experience in dealing with switchgears, transformers, instruments, motors, etc. Seeks position in Sales or Manufacturing. File No. 6303-E.

CIVIL ENGINEER. M.E.I.C., P.Eng. (Albt.) (U.N.B. 1959). Age 25, married. Two years' experience on hydro projects with consulting firm, including 6 months experience in supervision of field soils laboratory. For the past year employed by designing firm. Willing to work anywhere in Canada. File No. 169-C.

ILLUSTRATED is one of six Weir Size EF-100, 9-stage boiler feed pumps for Ontario Hydro's Richard L. Hearn Station —largest thermal generating station in Canada. Each pump is capable of delivering 735,000 pph of feed water at 2,300 psi. Metropolitan-Vickers motors —Vulcan-Sinclair hydraulic couplings. Consultants: Stone & Webster Canada Limited.

Representing the world-wide Weir organization for many years in Canada, Peacock Brothers Limited bring their own sixty years' experience to the application of Weir boiler feed pumps, condensers, feed water heaters and other well-known power plant auxiliaries.



Weir

G. & J. WEIR LTD.
GLASGOW, SCOTLAND

Represented in Canada by

PEACOCK BROTHERS LIMITED

MONTREAL

SYDNEY · TORONTO · SUDBURY · CALGARY · VANCOUVER

(Continued from page 149)

in Canada. On the short term basis, there are three project areas where management should increase productivity: labor-management relations; the field of vocational and technical training; and the field of method improvement and work study.

Nova Scotia was the first province to form a provincial productivity committee and, to date, two work study schools have been held. The province would also like to establish a National School of Productivity in co-operation with the Institute of Public Affairs of Dalhousie University. Those interested in productivity in Canada feel that Canada must lower its cost structure.

London

W. L. Thompson, M.E.I.C.
Correspondent

On Tuesday, March 20, 1962, at the Engineering Building of the University of Western Ontario, some 60 members of the Branch, with guests from the A.P.E.O., I.R.E. and A.I.E.E., listened to an illustrated subject entitled "Entry of Manned Space Vehicles into Planetary Orbit", written and presented by Professor B. Etkin, of the Institute of Aerophysics, University of Toronto.

Moose Jaw

R. J. Tomlinson, M.E.I.C.
Correspondent

A. S. Ringhein, Senior Project Engineer at the South Saskatchewan River Dam was the guest speaker at the Branch's March 28 meeting. Mr. Ringhein discussed progress and construction of the Dam from its start to the present. The talk was illustrated with color slides showing all aspects of construction. Mr. Ringhein outlined future construction and the possible problems which may be encountered.

The following were elected Branch officers for 1962-63: President, Flight Lieutenant V. L. McKinnon; Vice-President, M. S. Shelley, Secretary-Treasurer, G. C. Skorbohach.

Newfoundland

Anthony O. Nemec, A.M.E.I.C.
Correspondent

On April 14, the Branch members made a field trip to the Golden Eagle Refinery at Holyroad, 40 miles west of St. John's. At the time of the visit, a large tanker which transports crude oil from Venezuela, was pumping oil into the refinery's storage tanks. Members were taken on a tour through the refinery and were very impressed by the extent and application of the modern equipment which they saw in use there. The testing laboratory was another point of interest to the group which included 30 student members of the Branch.

Nipissing and Upper Ottawa

J. S. Cooper, M.E.I.C.
Correspondent

The branch held its annual President's visit and Ladies' night April 10 at the White Oaks Inn, Temiscaming at which Dr. D. G. Ballard, HON. M.E.I.C. spoke on Engineering in Canada. Dr. Ballard was introduced by J. F. Chantler, M.E.I.C. of Temiscaming. In his speech, Dr. Ballard discussed generally the engineering profession in Canada, emphasizing some of its more recent achievements. He advised that engineers must examine closely the social implications of their work. P. M. Rebin M.E.I.C. of Sturgeon Falls, thanked Dr. Ballard on behalf of the 63 members present.

University of Alberta

J. B. Osentor, S.E.I.C.
Correspondent

The Branch held a meeting March 22, at which Dr. Ford, Head of the Mechanical Department, University of Alberta, was the guest speaker. Dr. Ford described the new supersonic airliner being built by Britain and France. He indicated the research being done in Canada on high speed flight and described the wind tunnel at the National Research Centre. Two films were shown, "Farnborough 1960", a 30-minute film about the annual British air show. Although this was not technical, it was interesting to the members since it showed the latest of Britain's aircraft. "Four Figure Flight", a short film of the record-breaking flight of the Fairey Delta 2 in 1957, showed the actual

flight and the measuring instruments. The film was shown at high speed to illustrate the difference between the aircraft's speed and that of every day objects.

The new executive was elected at this meeting: Chairman is J. Osentor; Vice-Chairman, T. French; Secretary-Treasurer, D. Sanby, Advertising Chairman, Roger Patterson.

Winnipeg

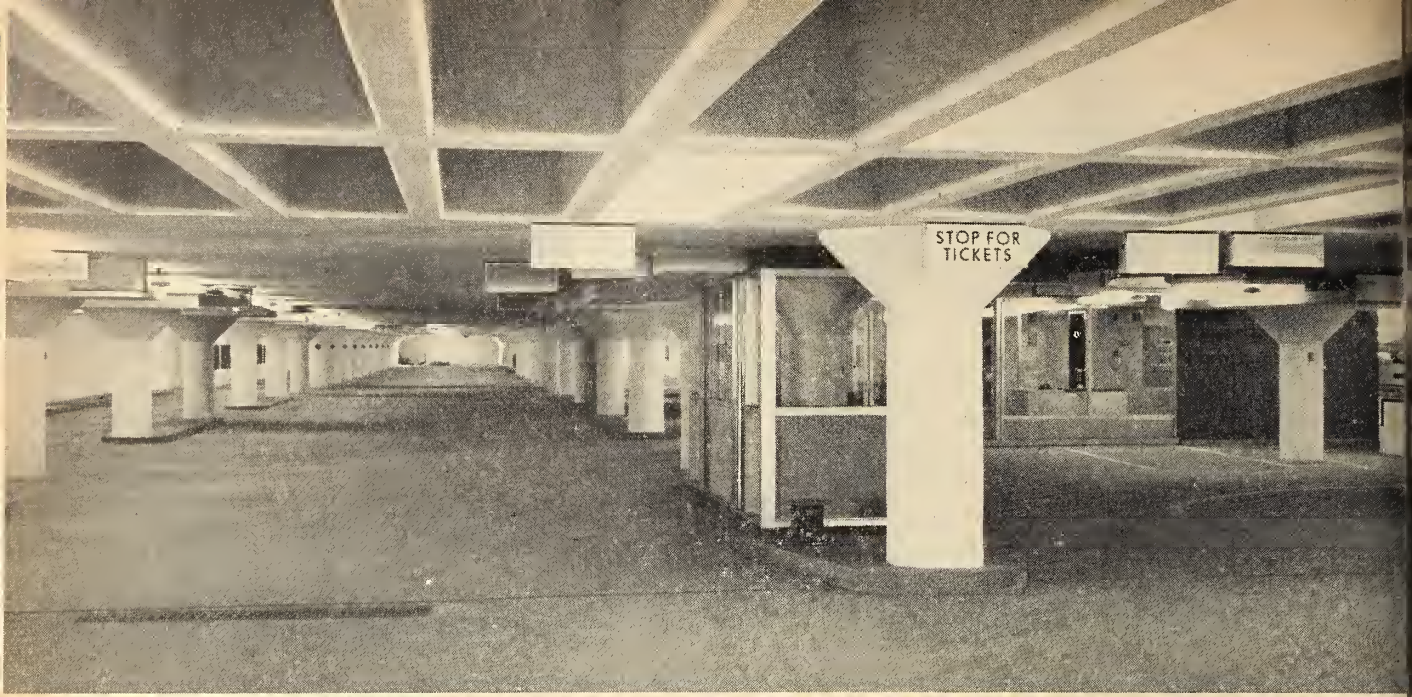
Foster W. New,
Correspondent

In his address to the March 15 meeting of the Branch, Dr. K. J. Charles of the Department of Sociology and Economics at the University of Manitoba, suggested that the engineer should take an interest in the economic problems of society. Some economic problems have been created by the activities of engineers, and some of them bear a striking resemblance to engineering mechanisms. Thus, by his interests, the engineer will be in a better position to make a more purposeful contribution to the welfare of society.

Dr. Charles then presented three problems to which engineers could beneficially apply their talents: the maintenance of sufficient growth rate of the Gross National Product; the understanding of the complex workings of the modern technological society; the effect of technological progress on society. Dr. Charles, during this discussion presented some reasons for the tardy growth rate of the G.N.P. in western Canada. He said that although there are differences between the economic and engineering system, there are areas where an engineering approach could be of benefit. He said that the effect of technological progress on society is not well understood, and if it were, the interest of the engineer would be benefited.

The annual students' night of the Winnipeg Branch was held at the Pembina Hotel in Fort Garry on March 22. Professor R. E. Chant, Chairman of the Branch introduced Dean A. E. MacDonald who outlined the terms of reference for the summer thesis prizes. Three engineering students, Cyril Howard, Civil; Nelson Zagalasky, Electrical; and Robert Chalmers, Mechanical, were presented with cheques and an Engineering Institute of Canada Bronze Medal.

After the presentation, N. Mudry reviewed the Institute's classes of membership. R. J. Roscoe, Chairman of the Student Section then introduced the speakers. J. Crawley, G. Denson and J. Hoogstraten, judges of the contest awarded first prize to Bill Fisher, a second year student who gave an interesting talk on what he thought could be done to improve engineering education. Bob Newbury, a fourth year Civil student, was second prize winner. He spoke on "Sedimentation Predictions of the South Saskatchewan Reservoir". His paper was based on model studies at the University of Manitoba. Les Crosthwaite, a fourth year Mechanical student, was third prize winner. He spoke on "Hydraulic Governors for Water Wheel Turbines.



In all these forms of constructio

Civic Square Underground Parking Garage, Toronto. Consulting Engineers: **H. K. Ferguson Co.** of Canada Ltd. Contractors: **Perini Ltd.**

McMahon Stadium, Calgary. Architects: **Rule, Wynn & Rule.** General Contractor: **Burns & Dutton Concrete & Construction Co. Ltd.** Supplier and erector of precast and prestressed members: **Con-Force Products Ltd.**

Steinberg Store, Riverside Shopping Centre, Eastview. Ont. Architects: **Dawson & Baker,** Montreal. Consulting Engineer: **Dr. Felix M. Kraus,** Montreal. Manufacturer of precast concrete shells: **Hochelaga Precast Structures, Ltd.,** Montreal. General Contractors: **Beta Construction Ltd.,** Montreal and **Geo. A. Crain & Sons Ltd.,** Ottawa.

CFCF-TV Building, Montreal. O **Canadian Marconi Company.** Arch **Paul Lapointe.** Engineering Ma **J. Creighton-Douglas.** Contractor: **Hewson Ltd.**

CANADA CEME

• Developments

(Continued from page 136)

THERMOVOLT'S new compact Program Controller contains the PEC Electronic Controller in a 7⅝" x 11⅜" panel-mounted case, together with a variable speed program cam, a cam-follower mechanism and an adjustable end-of-cycle switch. The instrument has one uncut transparent plastic cam. Once the program of a process is established the instrument can repeat the predetermined process-time cycle identically any number of times. It can perform two-step on-off; three-step on-off; and time proportioning control functions. The controlled process variable can be temperature or any other measurement which can be converted into DC voltage or current. Temperature ranges are available from −320°F to +5500°F.

MECHANICAL SHAFT seals, compact, self-contained units with all working parts enclosed within the seal housing, are available from Syntron (Canada) Ltd. A positive mechanical seal is established between the rotating and stationary parts in the seal. Syntron shaft seals are used to eliminate the leakage of gases or liquids around the rotating shafts of pumps, compressors, mixers, engines and other equipment. Type "M" seal will handle abrasive-free liquids at high or low temperatures with shaft speeds up to 3000 r.p.m.

ONE OF THE LARGEST mining fans ever produced in Canada, has been installed in the Gaspe Copper Mines Ltd., mine at Murdochville, Que. The single stage axial flow fan with cast aluminum variable pitch blades, has a wheel diameter of 120 inches, delivers 260,000 C.F.M. with 3.5 W.G. It was designed and manufactured by James Howden & Co. of Canada Ltd., Toronto.

A HERMETICALLY SEALED 4PDT relay featuring small size and extremely long life is offered by the Potter & Brumfield, Division of AMF Canada Limited. Slightly larger than one cubic inch, this KHS relay operates in environments calling for a sealed unit. Mechanical operating life is in excess of 100 million cycles. Load rating ranges from dry circuits up to 3 amps at 30 volts DC or 115 volts AC resistive. KHS relays meet the demands of such critical applications as data processing, and telephone carriers.

THE ALL-HYDRAULIC 6-inch capacity Staffa pipe bender, a heavy duty general purpose machine operating on a 4 hp. motor, has been announced by Affiliated Engineering Equipment (1961) Limited, of Montreal. This unit is completely enclosed and can be used for both bending and straightening. Steel pipes with up to 6-inch bore and steel sections up to 10 inches by 8 inches joists are easily handled. Maximum working pressures developed is 5000 p.s.i., and maximum power is 50 tons.

600 VOLT Type CM-O epoxy molded urrent transformer, featuring high netering accuracy 0.3B0.1, 0.3B0.2, .6B0.5, 0.6B0.9, 0.6B1.0, 1.2B2.0; an-utomatic short circuit link which be-omes operative when the cover is re-noved, small size, 4½ inch high and ¾ inch wide, and a continuous current ating of 150%. These current trans-ormers, introduced by Canadian Gen-ral Electric, are interchangeable with ll bar-type Canadian built indoor 600 olt 2 wire current transformers.

CANADIAN BROOMWADE of Toronto nas announced the introduction into Canada of a new gas turbine rotary compressor. The portable air power unit, known as the Broomwade Power Pack, requires no foundations starts in-stantaneously, runs without vibration and delivers 630 c.f.m. at 100 p.s.i. It can operate on a wide range of distillate fuels, has only a few moving parts, has no need for a coolant and is compact and versatile. The Power Pack, incor-porates simple control system with auto-matic safeguards.

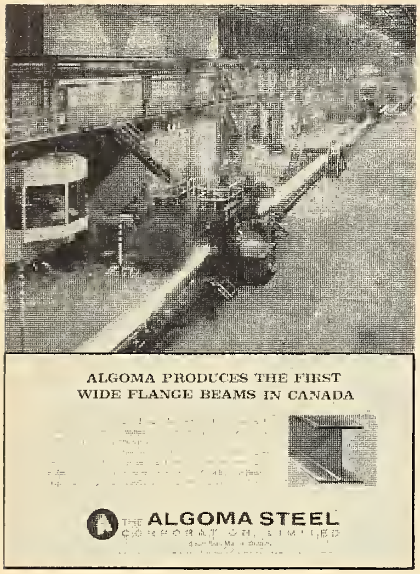
THE BRISTOL COMPANY of Canada Limited has announced the Dynamaster Transmittance/Linear Absorbance Re-corder which permits full-scale presenta-tion of three decades of linear ab-sorbance (optical density) with a range of 3.0-0 corresponding to 0.100% trans-mittance. Both absorbance and transmit-tance scales are linear. This recorder, designed to operate from any type of spectrophotometer with a millivolt out-put, provides absorbance readings with an accuracy of ±½% of absorbance span and ±¼% of transmittance span.

THE DROCO POWER CONVEYOR System has been introduced to Canadian industry by the Galt Wood Toll and Machine Company Limited. The con-veyors are available in straight, curved and floor-to-floor sections. The powered curves which are available in a wide variety of inside radii offer a substantial saving in space and manpower, and are of interest to those concerned with ma-terial handling problems.

TWO NEW LINES developed primarily for the original equipment and produc-tion markets have been introduced by Killark Electric of Canada Ltd. Series "Z" cord and cable connectors provide a greater mechanical sealing grip for the entrance of flexible cord and cables to electrical equipment. They are avail-able in a variety of sizes, both in the nut type and clamp type. Each type in-cludes a tapered rubber internal bushing which imparts a positive seal and a firm grip on the cord or cable. A series of close-coupled conduit elbows has also been developed in a variety of sizes, in 45 degree and 90 degree styles. They are produced in copper-free aluminum alloy by the permanent mold casting process for greater uniformity and overall quality.

(Continued on next page)

EIC CERTIFICATE OF ADVERTISING MERIT



Some advertisements are so striking that they become monthly aware winners whenever they appear. Such is the fortunate position the Algoma Steel Corporation Limited finds itself in with the winning advertisement for March, which appeared on page 65. The same advertisement won the award in our December issue.

The undoubted key to the advertisement's success was a remarkably colourful photograph of the mill floor in action with (presumably) the white hot flange beams being produced. Copy gave full credit to the Canadian mill builders and workmen involved, and quoted beam sizes available.

The advertising of Algoma Steel is under the direction of Mr. L. Brown, Administrative Assistant to the President. The winning advertisement was produced by the Toronto office of Cockfield, Brown & Company Limited, Mr. F. D. Adams, Account Executive.

Each month a different panel of fifty Journal readers from across Canada is asked to nominate an award-winning ad of their choice from the viewpoints of ACCURACY — INFORMATION — ATTRACTION.

• Developments

(Continued from page 169)

A LOWER COST abrasion and chemical resistant topping for concrete, wood and metal floors, has been introduced by the Tremco Manufacturing Co. (Canada) Ltd., Toronto. Tradenamed "Polytrem Flooring", this topping offers high resistance to acids, oils, grease, alkali, heated liquids and heavy steel wheel trucking. Surfaces protected with Polytrem require no priming.

AVAILABLE FROM Canadian Westinghouse is the Type SGR-18 automatic reclosing relay for ac circuit breakers with ac or dc control schemes. The reclosing circuit is energized in approximately one cycle after the breaker opens by the single reclosure, self-reset relay, and resets automatically after a time delay if the breaker trips immediately after initial reclosure. For ac control applications, the SGR-18 recloser contains an internally-mounted full wave silicon diode rectifier which provides a filtered dc output to the control circuits.

HIGH POWER SILICON rectifiers with a maximum peak reverse voltage rating to 1000 volts at 240 amperes are available from Canadian Westinghouse Company, Limited, Switchgear and Control Division. This line, type 439-P to 439-Z, is suitable for high-voltage, high-current applications including electrochemical refining, plating, elevators, cranes, railway traction and power supplies. The line features an alloyed junction, ceramic insulation, a lifetime hermetic seal, and hard solder construction which eliminates thermal fatigue problems. EIC

CONSULTING

SERVICES

• Library Notes *(Continued from page 128)*

SURVEY OF MINES 1962.

This thirty-sixth annual edition of the Survey gives information on thousands of Canadian mining companies, both active and inactive. Also included are maps of Canadian mineral areas, and tables showing mineral production, the price range of mining stocks, and the price range of metals. (Toronto, Financial Post, 1961. 338p., $5.00.)

BASIC MATHEMATICS, VOL. 3.

This third volume of a "pictured-text" course in mathematics shows how the various branches of mathematics are developed as working methods in mathematics. It covers orders of magnitude, binary arithmetic, possibilities and probabilities, differentiation, converging series, abstract functions, integration, conic sections, determinants and systems of coordinates. (N. H. Crowhurst. New York, Rider, 1961. 137p., $3.90.)

*RADIATION AND WAVES IN PLASMAS.

The papers constituting this book are based on seven talks presented during Lockheed's Fifth Annual Magnetohydrodynamics Symposium, held in Palo Alto in December, 1960. They cover kinetic equations for plasma and radiation; static equilibria, stability, and wave propagation in symmetrical collisionless plasmas; the electron-stream model of a plasma, and the problem of energy conservation in Landau damping; microwave emission from ultra-energetic plasmas; coherent wave propagation properties of plasmas; thermal generation of a fully ionized cesium plasma; and Alfvén-wave propagation. (Ed. by Morton Mitchner. Stanford, University Pr, 1961. 156p., $4.50.)

POPULAR LECTURES IN MATHEMATICS SERIES

Pergamon Press has published six volumes in this series translated from the Russian. The lectures were intended primarily for advanced high school students, and are as follows: volume 1, The method of mathematical induction by I. S. Sominskii; volume 2, Fibonacci numbers by N. N. Vorob'ev; volume 3, Some applications of mechanics to mathematics by V. A. Uspenskii; volume 4, Geometrical constructions using compasses only; volume 5, The ruler in geometrical constructions by A. S. Smogorzhevskii; volume 6, Inequalities by P. P. Korovkin. (London, Pergamon, 1961. each about 70 pages, about $1.50.)

*ELEMENTARY SURVEYING, 4TH ED.

Changes in this new edition of a basic surveying text for college and general use include a revision and expansion of the chapter on the theory of measurements and errors and limited coverage of the electronic instruments used in linear measurements. The use of the tape level, plane table, and compass are included with extensive coverage on the transit. In part II the more advanced material is introduced, with limited coverage of photogrammetry, field astronomy, boundary surveys, and industrial applications of surveying methods. (R. C. Brinker and W. C. Taylor. Scranton, International Textbook, 1961. 606p., $9.50.)

TECHNICAL PAPER PREPRINTS

Preprints of most of the technical papers to be presented at the Annual General Meeting of the Institute have been prepared. These will be sold at a special counter near the registration desk in the Queen Elizabeth Hotel during the Annual Meeting. They also can be ordered directly from the Institute.

The price is 50 cents a copy for papers up to eight pages in length, and $1 a copy for papers more than eight pages in length. Mail orders should be prepaid.

INDEX TO ADVERTISERS

JUNE 1962

PUBLICATION OFFICES: The Engineering Institute of Canada, 2050 Mansfield Street, Montreal 2, Quebec, Canada.

Association of Consulting Engineers of Canada Incorporated

The following firms have principals who are members of this Association engaged as professional engineers in engineering work independent of salaried employment or sales promotion.

The revenue derived from the sale of advertising space assists the Institute in publishing THE ENGINEERING JOURNAL on a regular monthly basis. Listed above are the names of the Companies and individuals whose advertisements appear in this issue.

ADVERTISING OFFICES

QUEBEC: J. E. Donovan, Manager Advertising, Sales Representative—Charles R. Amey, 2050 Mansfield Street, Montreal, Phone: VIctor 2-8121

ONTARIO: L. G. Barnum, Manager, Advertising Sales, 160 Eglinton Ave. E., Suite 103, Toronto, Phone: 485-0789

WESTERN CANADA: W. George Turner, 501 - 191 Lombard Ave., Winnipeg, Man., WH 3-9123

UNITED KINGDOM: H. A. Mackenzie, 4A Bloomsbury Square, London, W.C.1, England. Phone: HOlborn 3779

EUROPE: Gustav Elm, 41 Avenue Montaigne, Paris 8, France. Georg Linder, Wittelsbacher Allee 60, Frankfurt Am Main, West Germany.

NEW ENGLAND STATES: R. G. Melendy, 17 Maugus Avenue, Wellesley Hills 81, Mass. Phone: CEdar 5-6503

CHICAGO: W. Reynold Rotz, 549 W. Randolph St., Chicago 4, Ill. Phone: ST-2-8811

NEW YORK: John H. Boyd, 17 East 45th Street, New York, Phone: MUrray Hill 7-0654

CALIFORNIA: Dunkle/Lehmon Company, 740 South Western Ave., Los Angeles, Calif. Phone: DUnkirk 7-6149

EIC

THE
ENGINEERING JOURNAL

VOLUME 45 NUMBER 7 JULY 1962

UBLISHED MONTHLY BY THE ENGINEERING INSTITUTE OF CANADA, 2050 MANSFIELD ST., MONTREAL 2, QUE., CANADA • TEL. VI. 2-8121

Printed in Toronto

Price $6.00 a year in Canada, British Possessions, United States and Mexico. $7.50 a year in Foreign Countries. Current issues, 75 cents a copy, back issues from $1.00 per copy up. To members, affiliates and other bona fide engineers in Canada—no charge. Authorized as second class mail, by the Post Office Department, Ottawa, and for payment of postage in cash.

MEMBERSHIP

CCAB BNA

Indexed in
The Engineering Index
The Applied Science and Technology Index

CONTENTS

IN THIS ISSUE

In their paper, *"Building of Hemispheres of High Explosives from Cast Blocks"*, **W. J. Ditto**, Head of the Munitions Section, Defence Research Board of Canada, and **J. Holdsworth**, Technical Officer, also with the Defence Research Board, describe the investigations of shock and blast phenomena in free air brought about by a requirement for hemispherical explosive charges to be burst at ground level. The aim was to initiate the explosive from the centre and achieve a symmetrical shock wave through the surrounding atmosphere. No container or casing was to be used because debris would add difficulties to instrumentation, and might affect the symmetry of the shock wave produced. Cast hemispheres had been used in earlier experiments, but the requirement for progressively larger charges extending into the multi-ton range brought about the investigation of the block method of construction. This introduced several new and interesting problems, particularly in the preparation of the cast blocks of TNT of consistent high density, of smooth and regular surfaces so that they should fit closely together and of a size and shape that should be convenient to handle.

Highly compressible marine clay is the most common soil in the vicinity of Ottawa where many residential districts have been affected by differential settlements of foundations in this material. In an attempt to correlate degree of damage with soil characteristics and other environmental influences, detailed settlement studies have been carried out. In this paper, *"Soil Shrinkage Damages Shallow Foundations at Ottawa, Canada"*, **M. Bozozuk** shows that as a result of these studies, differential settlements are attributed to the influence of paved streets, sewers and trees, which tend to lower the ground water table. Loss of soil moisture causes the clay soil to shrink with the result that the surface of the ground settles. In hot and dry weather, the great demand for water by large trees increases the problem, and if the trees are situated too close to the streets or buildings large local settlements may cause considerable damage.

A man may enter mining engineering through either a two-year course in a technical school, more particularly the Provincial Institute of Mining, from the equivalent of Grade 12 in Ontario, or from a four-year course in a university after the equivalent of Grade 13 in Ontario. In his paper, *"Mining Engineer Education"*, **A. V. Corlett**, Head, Mining Department, Queen's University, states that about one-third to one-half of the entrants enter by the technical school route. The two groups start off evenly for traditionally "the only way to learn about mining is on-the-job", and the technical school men who have worked on a narrower program are as skilled at the technician level as the young engineer. The young engineer's skills were learned in the lower years at university, as a small part of his training.

The university student has spent about 30% of his time on fundamental studies common to all engineers and 50% on cognate subjects such as geology and metallurgy. Not much of his time was spent on strictly mining subjects. A mining engineer must know more about abstruse mine design forces than any other engineer knows about them. He must know the value of his ore, and must design systems to co-ordinate the work of men and machines to move it. The design systems which constitute mining engineering are based on data that has varying degrees of reliability. Mining engineering students are being educated to interpret those data. If industry does not recognize the utility and availability of that talent, our efforts are wasted.

In this paper, *"Magnetic Inverters—A Review of Switching Processes"*, **C. H. R. Campling**, M.E.I.C., Queen's University, **J. A. Bennett**, A.M.E.I.C., Queen's University and **C. H. O'Hara**, A.M.E.I.C of the National Research Council, discuss switching in single-phase inverters and transient locking phenomena in polyphase inverters The class of inverters with which the paper deals includes those in which the operating frequency and (for polyphase inverters) the electrical angles between phases are determined by the characteristics of the inverter transformers. Polyphase units of this type are known as self-locking inverters.

Two circuit arrangements are presented which permit the generation of pure rectangular voltage waveforms at arbitrary voltage levels with self-locking inverters. In addition a simple method is demonstrated for generating output waveforms which are stepped approximations to sinusoids.

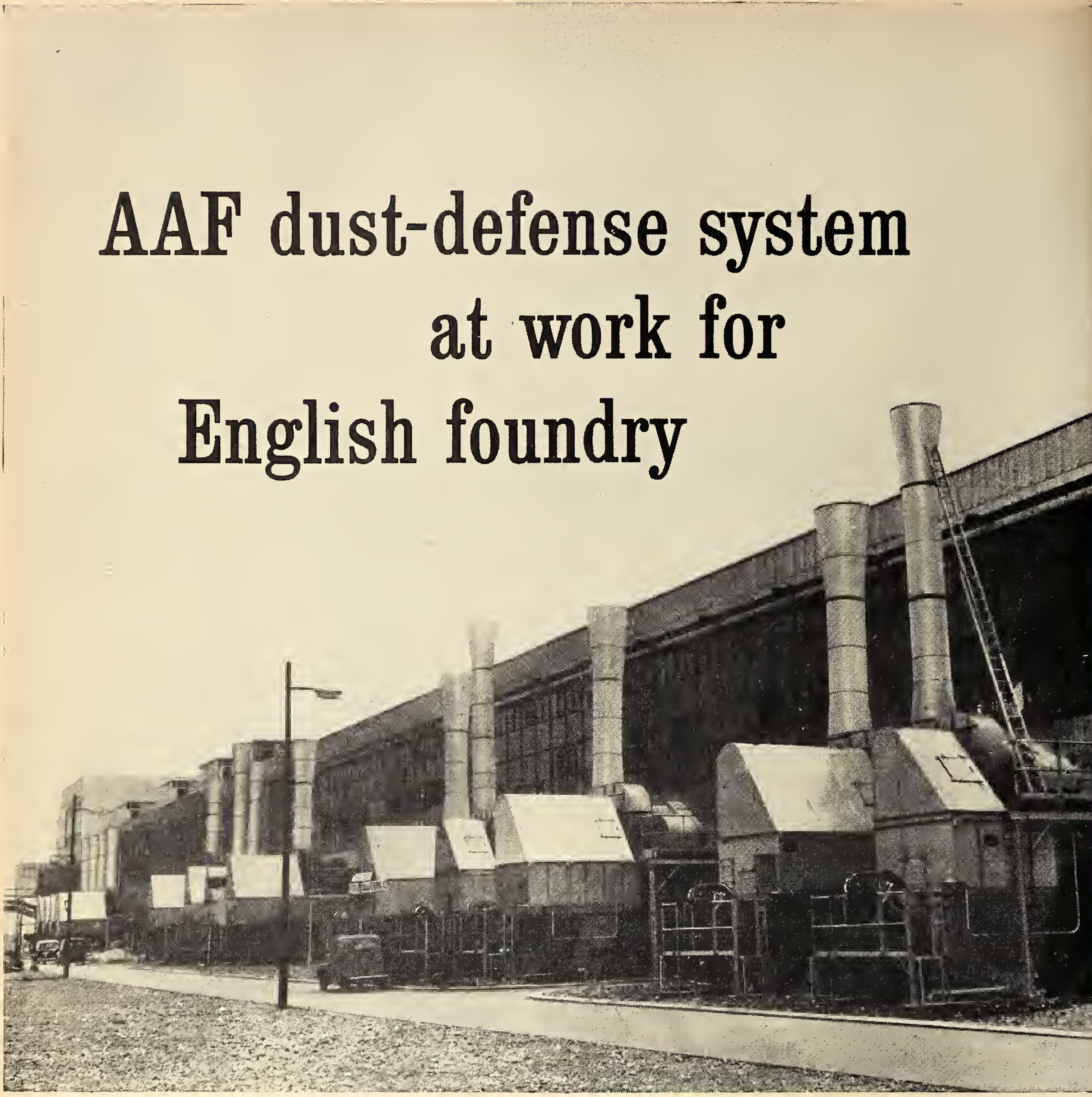
ERRATA

Due to a mechanical error, one complete page of the paper entitled, *"Modern Techniques Solve Unusual Log Driving Problems"*, by **D. M. Foulds** and **C. E. Davidge**, was omitted from the May issue of the Engineering Journal. We sincerely regret the embarrassment caused to the authors and the inconvenience caused to the many readers who brought this to our attention. Any reader wishing a complete copy of this paper, may obtain it free of charge by writing the Editorial Department of the Engineering Journal.

COVER ILLUSTRATION

The use of explosives is common in many engineering projects, and by many engineering disciplines. The cover illustration symbolizes this general use, and our lead paper. Photo courtesy Canadian Industries Limited.

AAF dust-defense system at work for English foundry



Dust is the universal foundry problem, the inevitable by-product wherever castings are made. Fortunately, the *solution* is universal too: AAF dust control.

A case in point is the new Thames foundry of Ford Motor Company, Ltd., at Dagenham, England. AAF collectors here are exhausting 700,000 cfm of dust-filled air from core sand mixing plants, core grinding lines, moulding lines, primary and vibratory knockouts, back-scrap and sand preparation plant, chipping and grinding lines and abrasive cleaning plants.

AAF's complete line of dust control equipment was application-developed, now challenges *any* foundry dust control problem—*anywhere.*

For more information, call your local American Air Filter representative or write us direct. Address: American Air Filter of Canada Ltd., 400 Stinson Blvd., Montreal 9.

6214

AAF CANADA

American Air Filter
OF Canada LTD.
400 Stinson Blvd., Montreal 9

BUILDING HEMISPHERES OF HIGH EXPLOSIVES FROM CAST BLOCKS 500 POUNDS TO 100 TONS

W. J. Ditto, M.E.I.C., *and J. Holdsworth*

INVESTIGATION of shock and blast phenomena in free air raised a requirement for hemispherical explosive charges to be burst at ground level. It was desired to create a symmetrical shock wave as from a point source on the ground. This was to be achieved by a charge of hemispherical shape, flat side down on the ground and initiated from its centre—that is, the centre of the base circle. No container or casing was to be used because debris was to be excluded from the initial wave front.

Five hundred pound cast hemispheres of TNT had been used in earlier experiments at the Suffield Experimental Station at Ralston, Alta. Because it was desired to extend the size into the multi-ton range it was apparent that solid casting might become impractical. Therefore it was proposed to build charges of approximately the desired shape from cast blocks. To relate the performance of the solid cast and the block built charges, the first block built designs were of the 500 lb. size. By using cast blocks 3½ in. x 3½ in. x 1¾ in. it was found practical to build a 500 lb. charge approximating a hemisphere and giving a performance on detonation which matched that of the solid cast hemisphere. Having achieved success in block building of charges of 500 lb. it was then decided to continue this system for charges of many tons. However, in the multi-ton range it was felt that the unit blocks should be larger and accordingly a programme was set in motion for casting TNT blocks of approximately 33 lb. weight, and dimensions 12 in. x 12 in. x 4 in. Figure 1 shows cross-sections of three charges constructed with these blocks.

Casting TNT Blocks and Booster Charges

It was a prime requirement to achieve high density, and small crystal size in the blocks as well as accurate shape and dimensions. Because TNT shrinks a great deal as it hardens, and because rapid cooling seems to produce the most desirable crystalline structure, it was decided to cool the molds with water from the bottom region and up the sides and maintain a "hot header" of liquid from the top down into the centre to fill in for shinkage. Single block molds were used. These were made from aluminium plate, pieces being grooved to fit, and held together with clamps. (Fig. 2)

The molds were arranged in groups of six inside rectangular aluminium water tanks and riding on aluminium hand trucks for easy movement from pouring room to cooling room and to the block removal room. Each water tank was equipped with a hose outlet so that water level could be controlled. (Fig. 3)

Two large double-walled aluminium tanks were used to melt Grade I flaked TNT. Water at temperatures around 97° C. was circulated between the walls of the tanks. A plunger type valve and spout at the base of each tank allowed pouring directly into the molds in position on the hand trucks. Long stemmed funnels were used to minimize the splash. Splashing of liquid TNT on to upper portions of the mold while filling the lower part causes "scaling" on the block due to prehardening of thin layers against the cool metal. (Fig. 4)

The molds were not pre-heated and TNT pouring temperatures of around 95° C. were found most suitable. About 3 in. of the header reservoir was filled to provide excess liquid.

Fig. 1. Cross Sections of Newer Charge Designs.

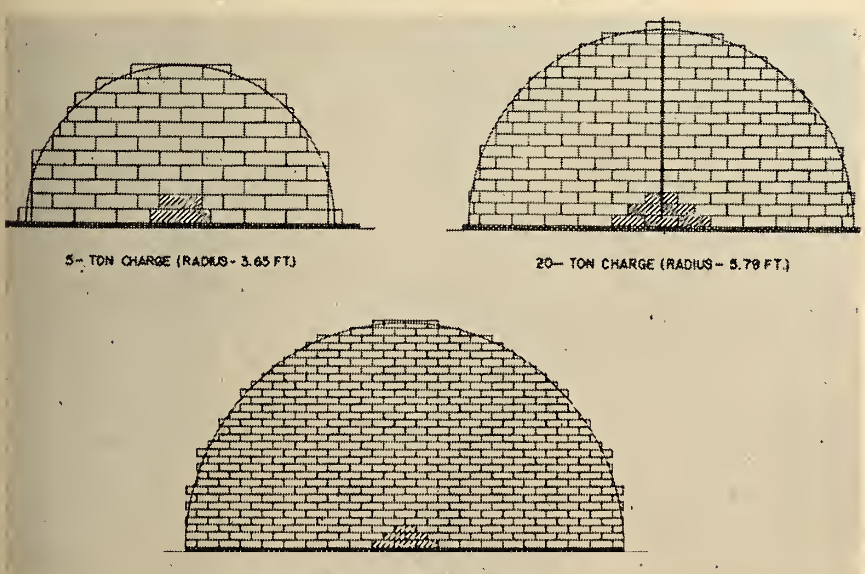
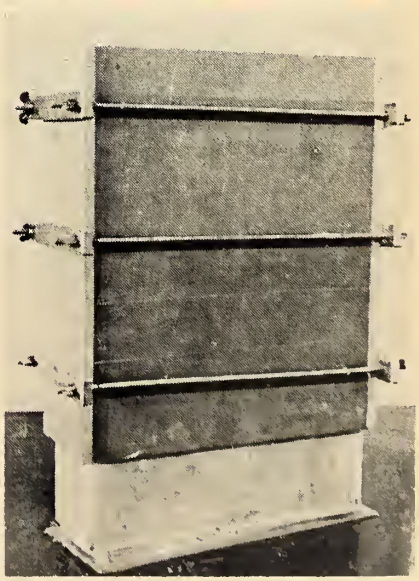


Fig. 2. Twelve Inch Block and Mould.



The molds were wheeled from the pouring room into the cooling room where cold water was available with suitable valves and tubing to fill the outer tanks with water.

In order to maintain a liquid header as the blocks cooled from the bottom and the sides, a steam probe was devised. This consisted of a brass tube about ⅝ in. in diameter, closed at the lower end and equipped with a smaller injection tube to heat it with steam. The steam probe was inserted down through the pouring hole in the top plate to ensure access of liquid into the central regions of the block.

It was found most satisfactory to cool the molds with water for about 45 minutes and then to allow four to five hours air cooling with the steam probes maintaining liquid at the top.

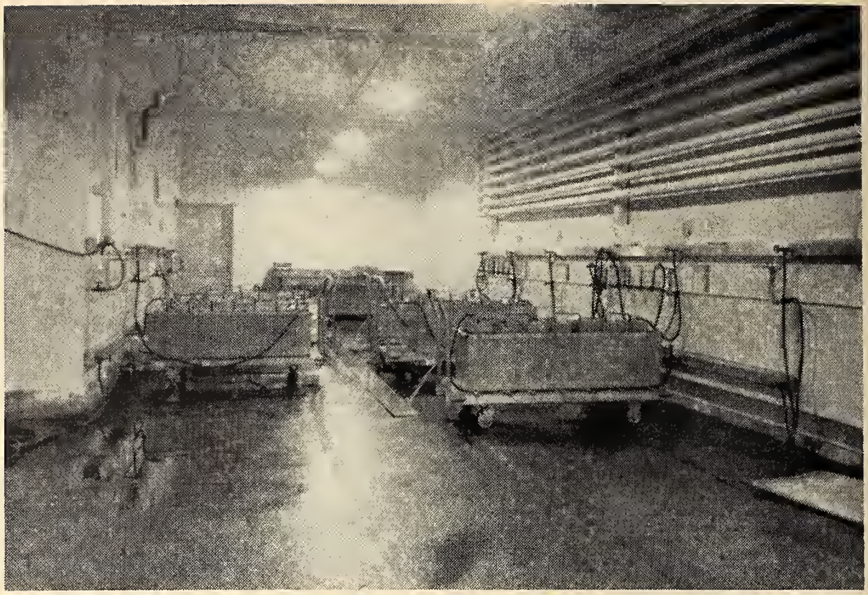


Fig. 3. Moulds with Water Baths and Steam Probes in Cooling Room.

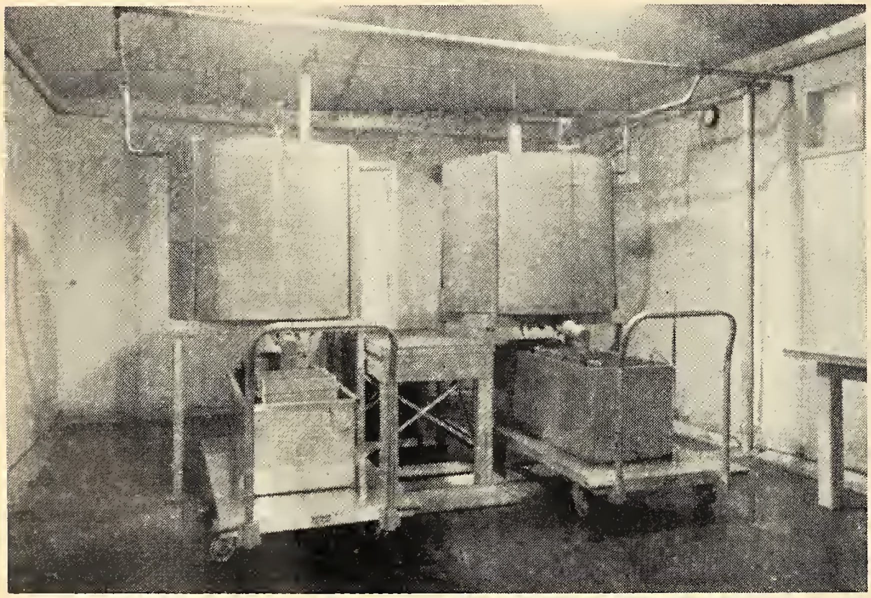


Fig. 4. TNT Melting Tanks with Molds in Position for Pouring.

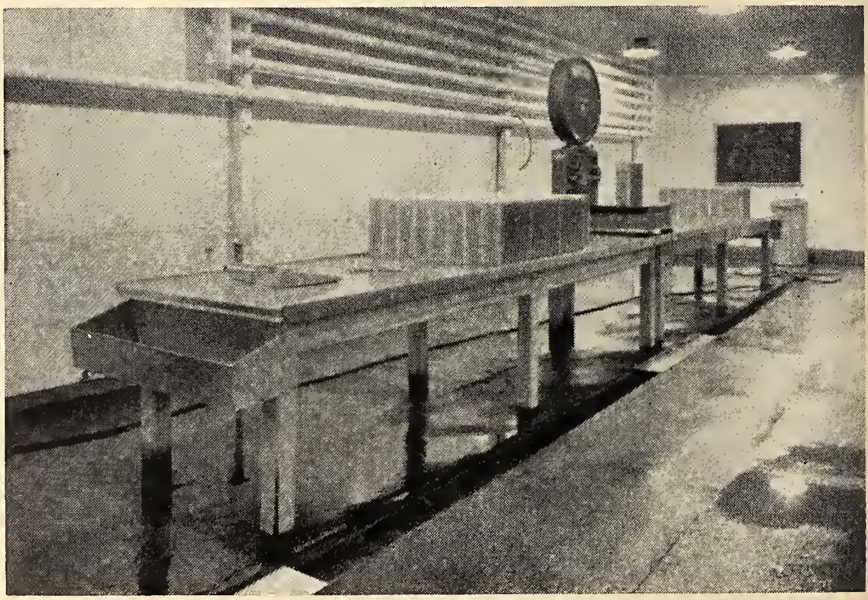
Tolerances for the blocks were set as follows:—

A. *Shape*
  (1) Faces flat within 0.05 in.
  (2) Large faces parallel within 0.2° of arc.
  (3) Mean distance between large faces 4 in. ± 0.02 in.
  (4) Edge faces parallel within 0.3° of arc.
  (5) Mean distance between edge faces 12 in. ± 0.03 in.
  (6) Adjoining faces at 90° within 0.3°.

B. *Surfaces*
  (1) Limit of surface pits on one face 1 in^2 area, max. depth 0.4 in., max. av. depth 0.1 in.
  (2) All projections to be removed.

C. *Density*
  Minimum density of any one block, 1.55.

Fig. 5. Finished Blocks Ready for Weighing.



After this period the probes were removed and the mold left overnight before removal of the blocks.

Because of further shrinkage after hardening it was found that the blocks slid out of the molds after removal of the base plate. To help remove the header block, it was found convenient to place a brass handle into the header after removal of the steam probe. On hardening of the TNT, this handle with one portion protruding from the top afforded a means of pulling the waste chunk from the top reservoir. After cleaning, the molds were lightly lubricated with silicon oil before reuse. (Figs. 5 & 6)

A high order of accuracy was required to ensure a close fitting pile.

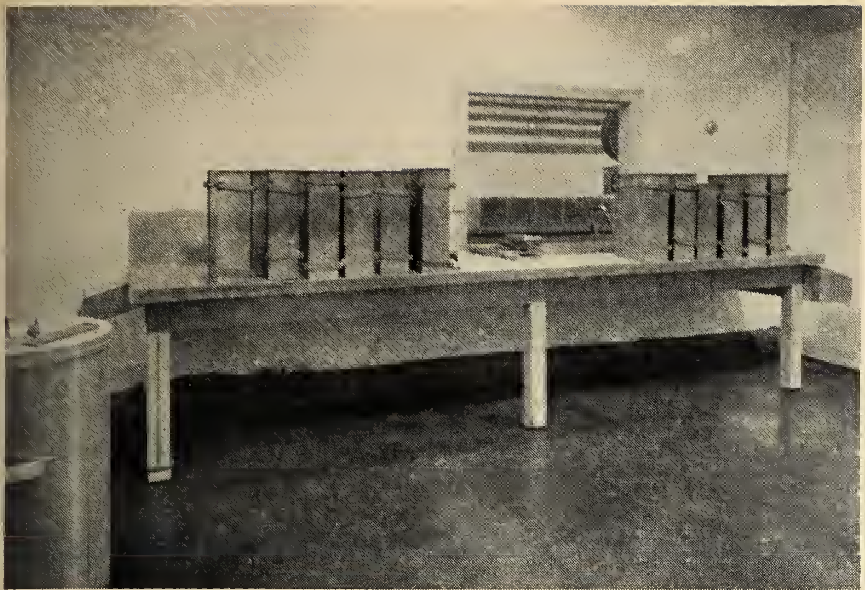


Fig. 6. Molds in Cleaning Room.

Some fractional size blocks were required for trimming the outside of the piles. Standard TNT blocks were cut with a phosphor bronze saw using a wooden mitre box flooded with water.

Booster charges were cast from Tetrytol, a mixture of crystalline Tetryl and TNT in proportion 70/30. For the five ton charges the booster consisted of two cylinders of tetrytol 4 in. high, one being 12 in. in diameter sitting on the other which was 17 in. in diameter. These cylinders were surrounded by specially cast TNT blocks which were curved to fit the contours of the cylinders. (Fig. 7)

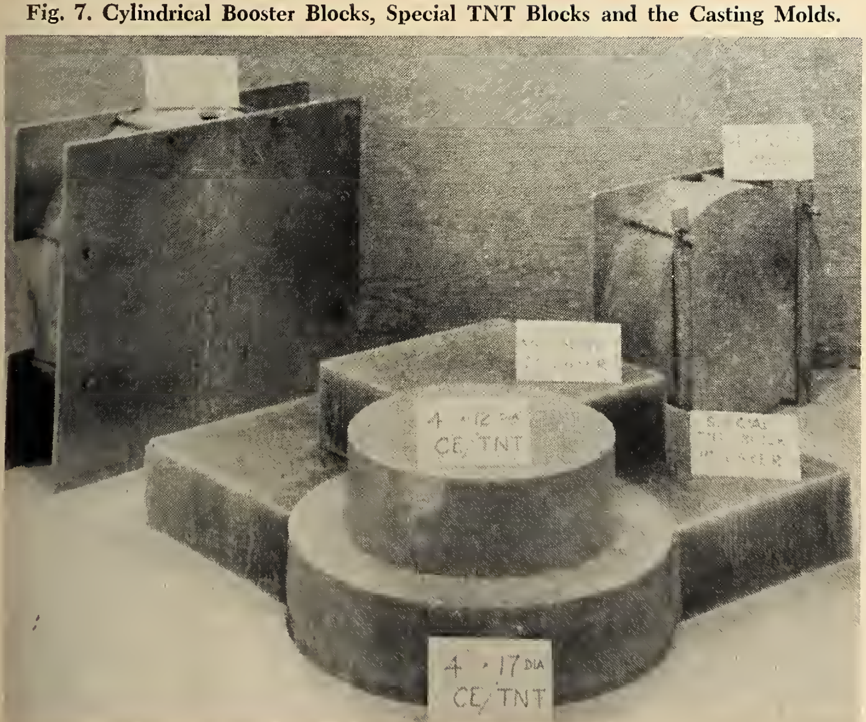
For the 20 ton and 100 ton charges the boosters were made up of standard size blocks of Tetrytol. These were cast using the TNT block molds, and weighed about 34 lb. each, with a density of 1.63.

Building Charges in the Field

For the five ton charges construction took but a few hours and therefore each of these was built on the morning of a trial. It was evident that in the case of the 20 ton charges about two days would be required for building. This raised new problems because of such things as weather hazards and the effects of solar radiation on exposed TNT. It was decided to place lightning rods on opposite sides of the charge and also to cover the charge with a suitable tarpaulin. When it came to constructing the 100 ton charge, something like a week would be needed. To give acceptable working conditions and a reasonable margin of safety from weather, dirt, etc., it was decided to use a shelter building which could be taken away on the day of the trial by removing one end and raising it onto wheels. The shelter building chosen was of a Nissen Hut type with laminated wooden arches and aluminium sheeting. (Fig. 8). The two flat ends were made of plywood, and two doors about 3 ft. wide were placed in one end to give access for supplies during building. The other end of the building was designed for easy removal. Lightning rods were mounted on the apex of the roof and electric lighting was provided inside with explosion-proof wiring and fixtures. To improve the accuracy of alignment in the field two transits were set up about 30 ft. from charge centre and sighted along two reference lines through the centre and at right angles to each other. These transits enabled the base to be positioned accurately and gave a quick check on block alignment at any stage of construction. For the hundred tonner, being constructed inside the shelter building, four plumb bobs were hung close to the walls to furnish reference lines.

Fig. 8. Shelter Building for 100 Ton Pile.

Fig. 7. Cylindrical Booster Blocks, Special TNT Blocks and the Casting Molds.



The charges were laid on two or three layers of ¾ in. plywood. A 4 oz. tetrytol primer was recessed into the centre of the plywood base and contained two cavities for detonators on opposite ends. Aluminium tubes were laid between adjacent sheets in the top layer leading to opposite sides of the pile and the charge was fuzed by inserting two detonators into the primer through these tubes. The detonators, of No. 8 commercial type, were wired in parallel to a capacitor-discharge firing box with 12 microfarad capacity charged to 1600 volts.

Special containers were designed for hauling the TNT blocks to the field. These were open top wooden boxes with inside dimensions of 4⅜ in. by 37 in. with plywood sides and bottoms and heavy wooden ends. They were lined with either soft rubber or thick corrugated cardboard. Each box held three blocks sitting on edge end to end. About 3 in. of the blocks sat above the top edge of the box so that they were convenient for lifting out. For transporting the boxes were placed on trucks in one layer only and covered with canvas for protection. As a precaution against static electric discharge, all boxes, covers, etc. were treated with lissapol anti-static agent.

Improvement in design and experience in the field increased the rate of building considerably. Construction of the five ton charge required as little as 45 minutes actual working time. The 20 ton charge was completed in two days and the blocks of the 100 ton charge, with some increase in crew, were actually stacked in three working days. (Fig. 9)

Fig. 9. 100 Ton Charge.

Measurement of Detonation Velocities and Symmetry of Detonation Wave

In the 20 ton charge, two ionization probes were installed. The first was located close to the base of the charge, just outside of the tetrytol booster. The distance from the centre to this probe was 18.5 in. The second probe was installed in layer seven at a horizontal distance of 65.5 in. from the centre and 26 in. above the base. The distance from the centre of the charge to this point was 70.5 in. Both probes were in the same direction in azimuth from the centre. The signals from the probes and also from the firing pulse to the detonator were recorded on Ampex Magnetic Tape in the "direct record" mode.

The following time intervals were measured.

(1) Firing pulse to first probe — 96 microsecs. (±2) *

(2) Firing pulse to second probe— 290 microsecs. (±2) *

The functioning time of the detonators from the time of the firing pulse has been determined from a recent series of experiments to be 23 μ secs (± 2).

Thus the time intervals from detonator functioning to wave arrival at the probes is calculated to be:—

(1) First probe 73μ secs ($\pm 4\mu$ secs)
Second probe 194μ secs ($\pm 4\mu$ secs)
giving velocities:—
Detonator to Probe 1—6400 m/sec
Detonator to Probe 2—6700 m/sec
Probe 1 to Probe 2—6800 m/sec

The detonation velocity for creamed TNT of density 1.6 has been given to be about 6800/sec. (1)

In the 100 ton charge, 12 ionization probes were installed. These were placed in three directions from the charge centre — six inner probes at approximately 28 in. from the charge centre, and six outer probes at about 119 in. from centre. Their locations were as shown at top of page:—

Direction from Centre	*Elevation above horizontal (approx.)*	*Inner Probe No.*	*Outer Probe No.*
N	0°	1	2
N	45°	3	4
(vertical)	90°	5	6
S	45°	7	8
S	0°	9	10
W	45°	11	12

*Estimated Max. Error.

The following velocities were calculated between respective inner and outer probes:—

Interval (Probe Nos.)	*Velocity (m/sec.)*	*Estimated Max. Error – (m/sec.)*
1–2	6750	120
3–4	6750	120
5–6	6800	95
7–8	6800	120
9–10	6770	120
11–12	6800	170

As an indication of the shape of the emerging detonation wave as indicated by the relative time of arrival at the six outer probe positions, the following distances from charge centre of the wave at one point in time (445μ secs after zero) have been calculated at bottom of this page:—

Probe No.	*Direction and Elevation*	*Distance from Charge Centre at 445μ sec.*	*Estimated Max. Error*
2	N – 0°	119.2 ins.	±2.0 ins.
4	N – 45°	118.4 ins.	2.1 ins.
6	vertical	118.7 ins.	1.7 ins.
8	S – 45°	118.2 ins.	2.1 ins.
10	S – 0°	119.0 ins.	2.0 ins.
12	W – 45°	118.7 ins.	2.4 ins.

The last table indicates that the detonation wave in the 100 tonner appears to have had good symmetry close to the surface of the charge. Although it is beyond the scope of this paper to treat the qualities of the resultant atmospheric waves, it might be mentioned that at the distances measured by both pressure gauges and photo-optical methods, excellent sphericity of the shock wave was observed.

Bibliography

(1) Cook, M. A. 1958 **The Science of High Explosives** Reinhold Pub. Co.

SOIL SHRINKAGE DAMAGES SHALLOW FOUNDATIONS at Ottawa, Canada

M. Bozozuk
Research Officer, Soil Mechanics Section, Division of Building Research.

FINE GRAINED SOILS are often very sensitive to changes in soil moisture content; when dried they shrink and when wetted they swell. The resulting ground movements introduce a serious problem in the design of shallow foundations. Torchinsky[14] and Baracos and Bozozuk[1] have reported building settlement problems in Eastern and Western Canada; Dawson[5] has reported on the foundation movements of small houses erected on expansive soils in the United States; Collins[3] and Isaacs[10] have described foundation problems in South Africa and Australia, respectively; and Ward[15] has shown that vertical soil movements depend on weather conditions in England.

Fig. 1. Damage caused by differential settlement.

Damage due to soil shrinkage is a serious problem in some parts of the city of Ottawa. In many residential buildings large cracks similar to those shown in Fig. 1 may be seen, and streets and sidewalks are affected. In many cases an undulating riding surface develops in a street bordered by a row of large trees (Fig. 2).

Fig. 2. Uneven settlement of sidewalk near large maple trees.

Site Studied

In 1954, the Division of Building Research of the National Research Council initiated a program to study the problem. An area 10 city blocks by three was selected for study. In general, the buildings within this area

are 2½-storey brick veneer structures resting on limestone block basement foundations. For the most part, they are single or double family units from 60 to 80 years old.

The soil profile consists of a 4-ft. to 6-ft. mantle of fine sand overlying a thick stratum of sensitive marine clay. The clay, known locally as Leda clay, was deposited in the marine environment of the Champlain Sea which existed in the Ottawa-St. Lawrence River Valleys at the close of the last glacial period. Gadd[8, 9] and Terasmae[13] have shown that the sea existed in late glacial time and that it was modified by the inflow of fresh water in several places. These clays were then exposed by the subsequent uplift which occurred after the glaciers had disappeared. Generally, the Leda clays are associated with high sensitivity, high water content and low strength. A detailed account of these properties is given by Eden and Crawford.[7]

Damage Surveys

A house-to-house survey was carried out to assess the extent of possible damage. A total of 574 structures were examined from the outside on two separate occasions and the damage graded according to the following scale:

Zone 1: No damage. Structures in very good condition.

Zone 2: Slight damage. Some hairline cracks occurring in the exterior brickwork, range of differential settlement 0 to 2 in.

Zone 3: Moderate damage. Cracks in the brickwork up to ⅛ in. wide, differential settlement up to 4 in.

Zone 4: Heavy damage. Cracks ¼ in. or more, window and door frames distorted, differential settlement up to 6 in.

Zone 5: Severe damage. Cracks up to 2 in. wide, window and door frames badly distorted and the walls out of plumb, differential settlement exceeds 6 in.

Some buildings had tilted as complete units with relatively little damage occurring. Although the measured differential settlements were quite large, exceeding the ranges given in the above scale, these cases were graded from no damage to moderate.

Figure 3 shows a damage intensity map based on the house surveys. There is no distinct pattern to the areas of damage intensity. Severe damage occurs in numerous isolated locations with the greatest concentration of heavy damage centred near Waverly and Lewis Streets in the south of the area and near Lisgar and Nepean Streets in the north. MacLaren, Somerset and Cooper Streets consist mainly of zones of no damage to moderate damage. Although all the houses are of about the same age and of similar construction, the principal difference appears to be that in these zones the lawns and gardens are given more care and the trees are much farther away from the structures.

Solar orientation of the houses appeared to have little effect on the location of settlements. Most of the houses appeared to slope towards the streets regardless of the damage zones. The worst damage occurred when trees grew close to the structures.

The damage survey was reported in more detail on 77 houses located along the south side of Waverly Street between Bank and Elgin; the south side of Somerset Street between Bank and Elgin; the west side of O'Connor between MacLaren and Somerset; and along both sides of Metcalfe Street between McLeod and Gilmour Streets. To determine settlement, elevations were measured around the perimeter of the house at the first brickline. Assuming that the houses had been constructed level, the amount of differential settlement was obtained.

Angular deformation in the walls

Fig. 3. Damage intensity map of central Ottawa.

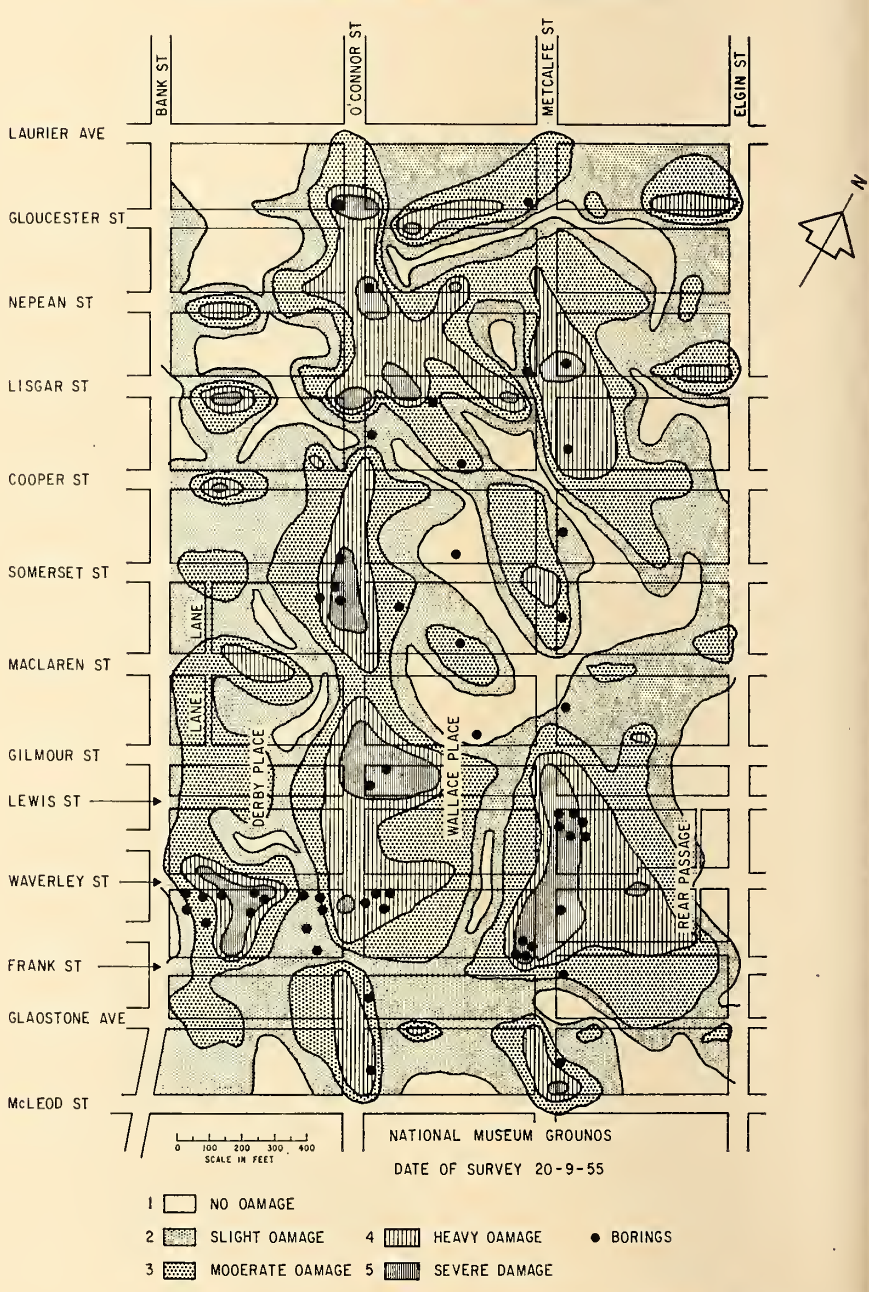


TABLE I

Analysis of Building Damage in Central Ottawa

Zone No.	Damage, degree	No. of Houses Surveyed	Cases with Trees Present, per cent	Distribution of Settlement,* per cent: Back	Side	Front	Differential Settlement, in.: Min.	Max.	Average	Angular Deformation
1	No damage	23	70	17	30	57	0.6	3.0	1.3	1/180 or 0.7 in. in 10 ft.
2	Slight	20	85	40	20	60	1.0	3.4	2.0	1/120 or 1.0 in. in 10 ft.
3	Moderate	17	88	18	29	77	1.7	5.3	3.1	1/90 or 1.4 in. in 10 ft.
4	Heavy	13	92	23	23	92	3.4	6.2	4.7	1/50 or 2.5 in. in 10 ft.
5	Severe	4	100	25	50	100	5.9	14.0	9.4	

*Settlements have occurred on more than one side of some houses. Therefore the total per cent distribution of settlement for front, back and side may exceed 100 per cent.

was determined by dividing the maximum differential settlement by the distance over which it occurred, using a minimum distance of 10 ft. for this purpose. Houses which had tilted and were undamaged had very small angular deformations. The results of the survey are given in Table I.

Relation of Deformation to Damage

The average settlement in the "no damage" zone was 1.3 in., producing an angular deformation of 1/180 or 0.7 in. in 10 ft. Badly damaged houses had an angular deformation of 1/50. Skempton and MacDonald[12] showed that the maximum angular deformation for "no damage" conditions for large heavy structures was 1/300, which is considerably less than that measured in this survey. They concluded, however, that if settlement proceeded at a slow enough rate, much larger deformations could take place without damage to the structure.

The National Bureau of Standards has issued numerous building materials and structures reports giving the results of racking tests on 8 ft. by 8 ft. walls made of various building materials. These tests were reviewed and an angular deformation at first crack determined for various walls by dividing the strain by the wall height. Angular deformations were obtained for wood frame walls sheathed in fiberboard, plywood, gypsum board and plaster, and for walls constructed of clay tiles, brick and concrete blocks. These results are given in Table II.

The racking tests described in these reports[17] show that wood frame walls are more flexible than solid masonry walls by a factor of 10. Fiberboard, plywood, gypsum board and plaster walls can withstand an angular deformation of from 1/60 to 1/270 in the laboratory, whereas solid masonry walls withstood values of only 1/500 to 1/1000. Field observations in Ottawa show that masonry walls have withstood angular deformations of 1/180 without distress. Deformations in the field occurred, however, over a period of 60 years or more, a very slow rate of deformation compared with the laboratory tests which were completed in a matter of hours.

Soil Survey

Fifty-five soil borings were made in the various zones at the locations shown in Fig. 3 in order to correlate damage intensity with soil type. The borings were made by hand with a 1½ in. spiral auger to a maximum depth of 14 ft., and the disturbed soil samples tested in the laboratory. The water contents, maximum liquid limits and the plastic limits of the soils in the five zones are plotted in Fig. 4.

There is no distinct change in Atterberg limits of the soil from one zone to the other. The plastic limits in every case vary from 25% to 30% and the liquid limits from 70% to 80%. The mean water content in relation to depth, determined mathematically by the method of least squares, shows that it is similar in the five zones. The principal difference is that the maximum range in water content is greater in the zone of severe damage than in the zone of no damage. The maximum moisture content deviation from the mean in zone one was about 13%, in zone three about 19% and in zone five about 27%. It appears that the degree of damage is reflected in the variation in the water content of the soil, and that this variation has resulted from differential degrees of drying.

Borings made near a house at the corner of Metcalfe and Frank Streets showed that the average water con-

Fig. 4. Properties of the soils in the five zones of damage in central Ottawa.

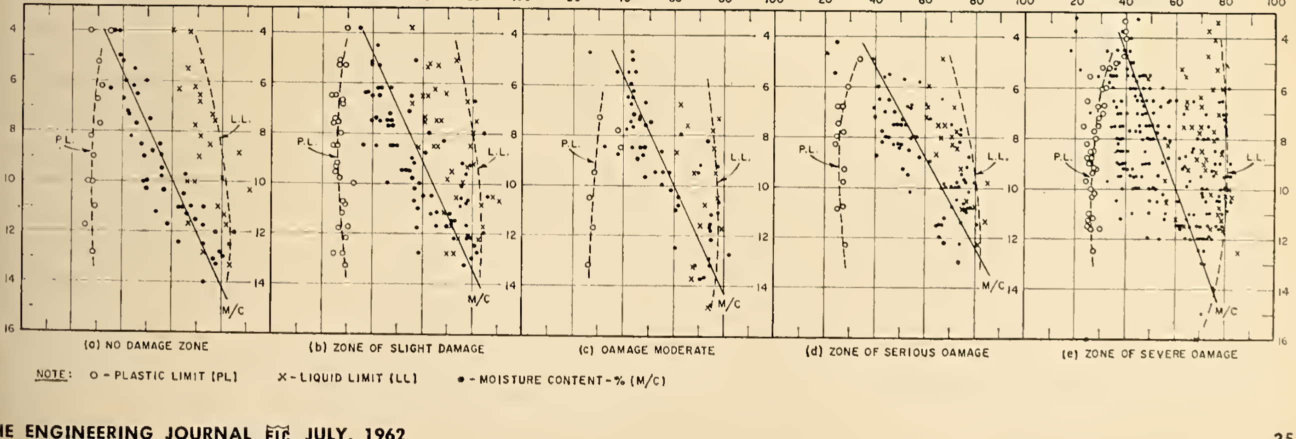


TABLE II

Angular Deformation at First Crack (Cracking Modulus) Obtained from Racking Tests on 8 x 8 ft. Walls of Various Materials.

*Description of Wall**	*Angular Deformation Ratio*
Fiberboard or plywood facing on wood frames	1/60 to 1/170
Gypsum board or fiberboard with plaster on wood frames	1/150 to 1/270
Structural clay tiles with cement-lime mortar	1/1000
Clay brick units with cement-lime mortar	1/500 to 1/1000
Concrete block units with cement-lime mortar	1/1000

*See the list of references for the NBS reports used in developing this table.

tent of the clay soil from a depth of 6 to 12 ft. was 50% near the point of maximum settlement and 75% at the opposite side of the house where no settlements were measured. In other locations as well, the driest subsoils were always found where maximum settlements occurred. This was generally in the front of the house facing the street as shown in Table I.

Three open standpipes were installed to a depth of 12 ft. between Frank and Waverly Streets at the locations shown in Fig. 5 in order to measure variations of the ground water table. Observations for the period 1955 to 1957 showed it to be always 3 to 5 ft. lower near the paved streets than in the middle of the back yard. It is clear that the streets tended to drain away surface water, causing a lowering of the ground water table and a gradual drying out of the subsoil. Sewers running beneath the streets would also contribute to drainage of free water.

Influence of Trees

From the initial damage survey it was evident that large trees were causing most of the trouble through their ability to draw water from the soil and pass it to the atmosphere by transpiration. Croney and Lewis [5] have shown that vegetation can cause considerable damage to roads in periods of drought. Ward [15] and Skempton [12] attributed building damage to the action of fast-growing trees. Based on these investigations, the British Building Research Station recommended that structures be separated from trees by a "safe distance" equal to the height of the trees [4].

Special gauges were installed at various depths and distances from a row of 55 ft. high elm trees growing in Leda clay at the Building Research Centre [2] to study the effect of tree root systems on soil water content and ground movements. The results for 1955 replotted in Fig. 6 show that even at a depth of 13 ft. a vertical movement of ½ in. was recorded within a horizontal distance of 20 ft. At a depth of 5 ft., common for foundations in the area, the movements varied from a maximum of 2¼ in. 5 ft. from the trees to ¾ in. 30 ft. away. Figure 7 shows that trees have a considerable effect on the ground water table and reduce the soil water content by 5 to 15%.

Mechanism of Soil Movement

The mechanism which appears to have caused increasing settlement of shallow foundations over a period of years can be explained from field and laboratory observations together with soil physics considerations.

Leda clay retains a high water content in its natural state. It is characteristic of marine clays to settle out in a flocculated structure with a particle arrangement in which edge to face contact is dominant [11]. Warkentin and Bozozuk [16] have shown in the laboratory that this clay exhibits large volume shrinkage on drying, with limited swelling on rewetting. During shrinkage the plate-like clay particles are thought to align themselves into a more nearly parallel arrangement as they approach each other. Due to the low osmotic swelling and the changed structure, the clay will not regain its original state on rewetting. Swelling in the vertical direction is greater than in the horizontal. Repeating the drying and wetting cycles decreases the regain further owing to the additional reorientation of particles. Eventually a point may be reached when no further reorientation of particles can take place. At this time the volume changes should be reversible.

The degree of drying and the number of dry-wet cycles will govern the amount of volume regain upon rewetting in the field. The natural shrinking and swelling of the surface soils are probably completely reversible because of the frequent dry-wet cycles they have experienced. Growth

Fig. 5. Annual ground water table fluctuation from Frank St. to Waverly St.

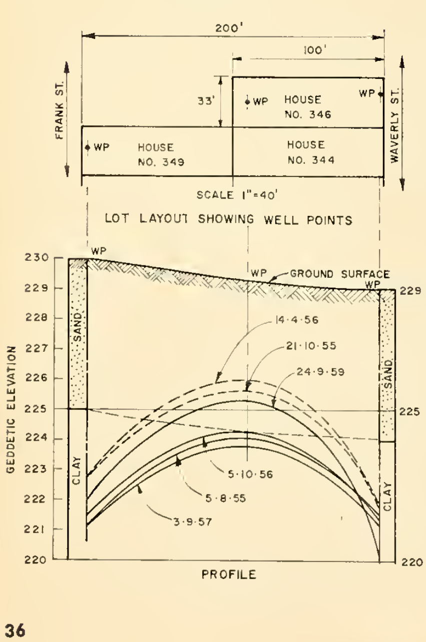
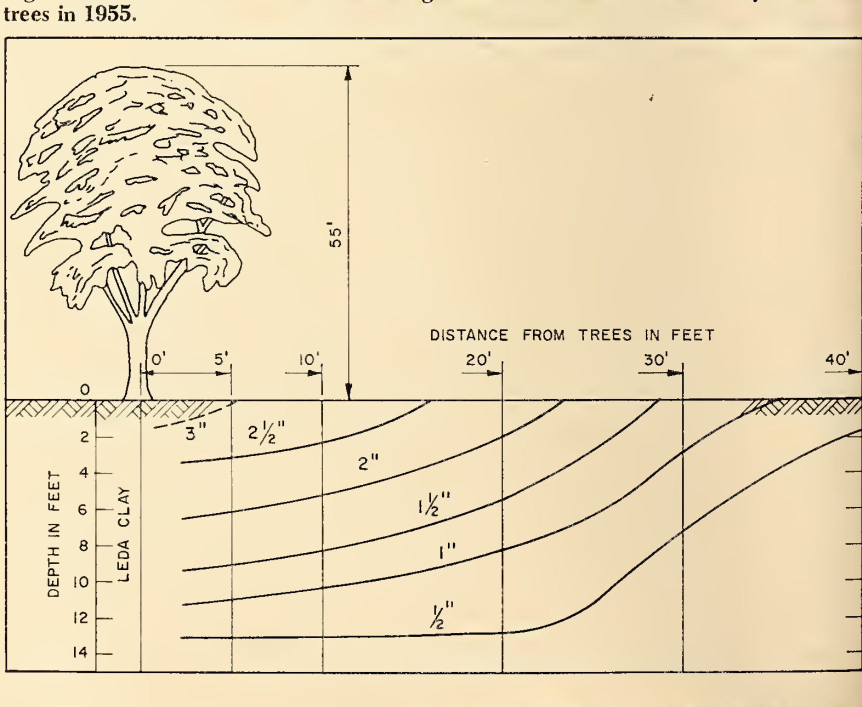


Fig. 6. Variation in maximum vertical ground movements in Leda clay near elm trees in 1955.



of large trees in these soils causes them to dry out to much greater depths, much more soil is subjected to drying and wetting, and the ground movements consequently become much greater. The decrease of soil moisture and the change in the structure of the soil accounts for the depressions around the trees and the large differential settlements in streets and structures. Similarly paved streets and sewers which intercept and drain away surface water cause the soils to dry out gradually and to shrink. This process is not reversible. Rewetting will not restore completely the original volume.

Based on this reasoning it is apparent that frequent surface watering to prevent the clayey subsoils from drying out will reduce shrinkage during the summer. Small trees, or those which do not require large amounts of water, should be selected for new planting. Large, fast-growing trees should be kept as far away as possible from houses with shallow foundations. In addition, placing foundations at such depths where seasonal moisture changes are small and far from trees and streets will lessen the risk of foundation movement.

Conclusions

A survey of residential buildings in central Ottawa revealed a wide range of damage intensity due to settlement. The maximum angular deformation for no damage conditions in brick houses appeared to be 1/180. Greater angular deformations produced cracks in the exterior walls. Laboratory racking tests carried out by the U.S. National Bureau of Standards showed that masonry walls could only withstand deformations of 1/1000, although wood frame walls could withstand much greater deformations without damage.

An investigation of the properties of the soil in the five zones of damage showed no distinct variations. There was a greater variation in the water content of the soil, indicating greater differential shrinkage, in the zone of severe damage than in that where no damage occurred.

Paved streets and sewers tend to drain away surface water and cause a lowering of the ground water table and a reduction of the water content of the soil. The subsequent shrinkage in soil volume changes the structure of the soil and causes settlement of the ground surface. Consequently buildings on clay soils in Ottawa show greater settlements on the sides facing paved streets.

Large trees can cause severe settlements in buildings and damage to streets and sidewalks. By removing water through their root systems they cause a local drying out of the soil. The resulting non-uniform settlements can cause severe cracking in buildings and a "roller coaster" surface in a roadway.

Drying of undisturbed Leda clay breaks down its flocculated structure, forcing the plate-like particles into a more nearly parallel arrangement. Because it also has low osmotic swelling, this clay does not completely regain its original volume on wetting.

To minimize the effects of ground movements in clays, lawns and gardens should be watered frequently during the summer months to prevent the soil from drying out. Trees should not be planted too close to structures, and if possible foundations should be placed at a depth in the soil where seasonal moisture changes are a minimum.

Acknowledgements

The author is indebted to C. B. Crawford, head of the Soil Mechanics Section of the Division of Building Research, for his assistance and direction in this study. The paper is a contribution from the Division of Building Research, National Research Council of Canada, and is published with the approval of the Director of the Division.

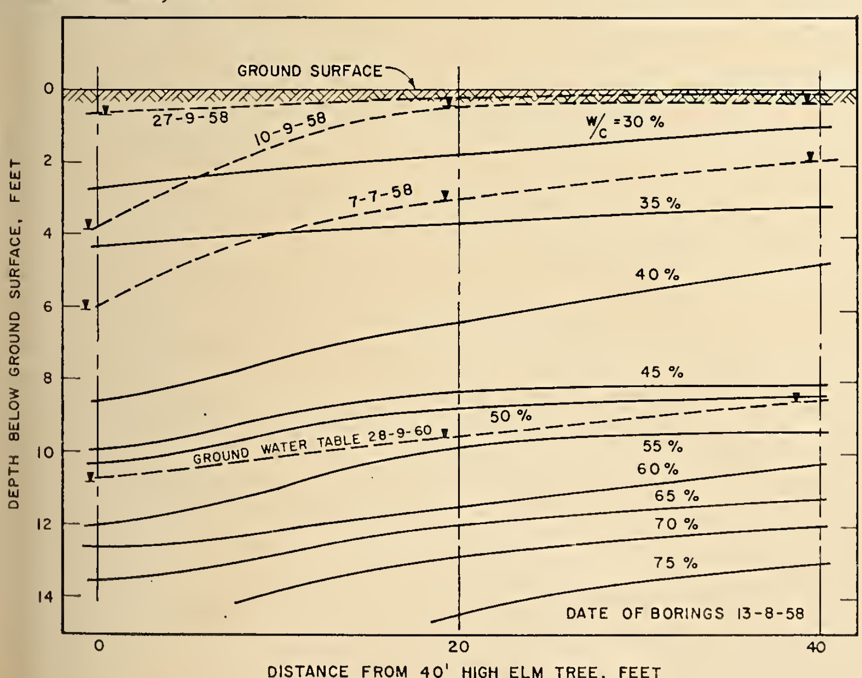


Fig. 7. Water content variation in Leda clay near a 40 ft. elm tree at the Building Research Centre, N.R.C.

References

1. Baracos, A. and M. Bozozuk. **Seasonal movements in some Canadian clays.** Proc. Fourth International Conference on Soil Mechanics and Foundation Engineering, Vol. 1, p. 264-268, 1957.
2. Bozozuk, M. and K. N. Burn. **Vertical ground movements near elm trees.** Géotechnique, Vol. 10, No. 1, p. 19-32, 1960.
3. Collins, L. E. **Some observations on the movement of buildings on expansive soils in Vereeniging and Odendaalsrus.** Symposium on Expansive Clays, Part 1, South African Instn. Civil Eng., Vol. 7, p. 273-285, 1957.
4. Cooling, L. F. **Some foundation problems in Great Britain.** Building Research Congress, Division 1, Part 3, London, p. 157-164, 1951.
5. Croney, D. and W. A. Lewis. **The effect of vegetation on the settlement of roads.** Instn. Civil Engineers, Proc., Conference on Biology and Civil Engineering, p. 195-202, September 1948.
6. Dawson, R. F. **The movement of small houses erected on expansive clay soil.** Proc. Third International Conference on Soil Mechanics and Foundation Engineering, Vol. 1, p. 346, 1953.
7. Eden, W. J. and C. B. Crawford. **Geotechnical properties of Leda clay in the Ottawa area.** Proc. Fourth International Conference on Soil Mechanics and Foundation Engineering, Vol. 1, p. 22-27, 1957.
8. Gadd, N. R. **Geological aspects of Eastern Canadian flow slides.** Proc. Tenth Canadian Soil Mechanics Conference, National Research Council, TM 46, p. 2-8, 1957.
9. Gadd, N. R. **Surficial geology of the Bécancour map-area, Quebec.** Geological Survey of Canada, Paper 59-8, 1960.
10. Isaacs, D. V. **Footings for houses, flats and schools.** Commonwealth Experimental Building Station, Special Report No. 8, Sydney, Australia, 1952.
11. Rosenqvist, I. Th. **Physico-chemical properties of soils: soil-water systems.** Proc. American Society of Civil Engineers, Part 1, Vol. 85, No. SM2, p. 31-53, 1959.
12. Skempton, A. W. and D. H. MacDonald. **The allowable settlements of buildings.** Proc. Instn. Civil Engineers, Part 3, Vol. 5, p. 727-784, 1956.
13. Terasmae, J. **Notes on the Champlain Sea episode in the St. Lawrence Lowlands, Quebec.** Science, Vol. 130, No. 3371, p. 334-336, 1959.
14. Torchinsky, B. B. **Foundation movements on highly plastic clays.** Proc. Sixth Canadian Soil Mechanics Conference, Winnipeg. National Research Council, TM 27, p. 37-45, 1953.
15. Ward, W. H. **Soil movement and weather.** Proc. Third International Conference on Soil Mechanics and Foundation Engineering, Vol. 1, p. 277-282, 1953.
16. Warkentin, B. P. and M. Bozozuk. **Shrinking and swelling properties of two Canadian clays.** Submitted to the Fifth International Conference on Soil Mechanics and Foundation Engineering, to be held in Paris, France, July 1961.
17. U.S. National Bureau of Standards. **Building Materials and Structures Reports No. BMS 5, 18, 21, 31, 32, 38, 42, 47, 48, 72, 86, 90, 104.** Washington G.P.O.

EIC

MINING ENGINEERING EDUCATION

A. V. Corlett, M.E.I.C.
Head, Department of Mining Engineering, Queen's University

A FADED PICTURE of a mining engineer represented him as an ingenious fellow, able to cope with any emergency, but not particularly urbane. He really was a rough diamond, quite at home in a ballroom when he shed his corduroys, flannel shirt and high boots. He didn't actually have much engineering talent but he could get things done.

Ten per cent of all engineering students graduated in mining engineering then. Mineral production in Canada was valued at about $225 million. The rough diamond has lost his glamour, and now only about 2% of engineering students graduate as mining engineers. Mineral production in Canada is now valued at more than $2,000 million.

Unfortunately the image was believed by too many mining engineers and employers of mining engineers. Much of the capability of the young graduates was lost through neglect to develop them. Their entry into mining engineering was through the labor force, learning to do by doing, or through the survey office.

Industry is aware that the graduates of a technical school can learn to do by doing as well as university training was in skills. What is more, graduates can, and they can probably do better, as surveyors or assayers, because a higher percentage of their after being instructed in the skills, they did not spend another two years studying theories. A third to a half of the entrants to mining engineering staffs are from the Ontario Provincial Institute of Mining. A good man, with a technical school background, can excel in mining engineering and if he can excel in mining, he would be a good man anywhere.

Mining engineering is difficult. The engineer has to contend with the perversity, not only of inanimate objects, but of men. The complexity of operation and the competition from other countries is increasing.

This paper is intended to objectively examine the field of mining engineering, and what must be done in education, to meet the increased demands on the profession, with newly recognized principles. Mining is not the only field that can use the new developments in mining engineering and there is an attempt to provide other engineers with information that may help in some of their problems.

The term "optimum" will be used frequently. It implies a compromise among the elements of a system. A program may call for something less than the best from one or more elements but still be the best overall solution to a problem.

Scope of Mining Engineering

A mineral industry project is initiated by a discovery of valuable mineral and the end product is a commodity that will meet the requirements of a purchaser. Geology is the study of the combination of events that bring about a concentration of minerals that can be worked at a profit. It also provides structural information that is valuable to the mining engineer in rock mechanics. The end product is usually processed by a metallurgist. The mining engineer works in the middle area. He is the man responsible for the production of the mineral. His scope, if shown by a graph between an ordinate representing the geologist's field and another representing the metallurgist's field, resembles the curve of a normal distribution, intersected on one limb at about one standard deviation, on the other limb by the metallurgy field, again at about one standard deviation. The overlap is needed to provide the mining engineer with a sufficient appreciation of the kindred fields to properly design, operate, and valuate the project.

Valuation is a test of his activities but the central area under the curve is his and the principal activities are ground control and materials handling.

Ground Control

The long-standing approach to ground control is trial and error, tempered by experience. Mining is a one-shot operation. An error cannot be corrected. The site can be abandoned, or remedial action taken, but the process is expensive. The result of an error may not be apparent for years and then it may only be revealed by destructive rock-bursts. Experience has been the only guide available, but during the past few years, progress has been made toward establishing a rational, scientific approach to ground control.

The breaking strain is well known to engineers, but most engineers are in control of the forces that could bring it about, and they work with materials whose behaviour is predictable. The mining engineer is not in control of the forces that he designs against, or the materials entering into ground control. He has to learn to recognize them and accommodate his excavations to either utilize or neutralize them. If he is wrong, he cannot tear the structure down and start over again.

Materials Handling

The mining engineer takes ore from in place and moves it out of the mine. He must do it efficiently. Iron ore is worth less than $11.50 per ton at Lake Erie ports, and South American mines are competitors there. It is cheaper than dirt at Knob Lake more than 1300 miles away by rail and water routes.

The objective of material handling is the optimum cost and the agencies are people and equipment. Equipment must be chosen carefully. Capacities and cost are high. So is the skill required by equipment operators. The engineer must be able to organize and direct their work. The boss cannot just point and kick.

Systems are built around equipment. Balance is a prerequisite. That involves allocation, linear programming, scheduling, and queueing problems. These are only formal names for what has been done for years in an informal way, when the stakes were not so high. The engineer must be prepared to meet that challenge, and others that are not yet recognized.

Mining Engineering Curricula

Certain fundamental studies are common to all branches of engineering—English, mathematics, physics, chemistry and mechanics of materials. That program is accompanied by training in skills — surveying, drawing, and laboratory measurements — which are introduced in the first and second years, but receive limited attention thereafter.

Other subjects required for mining engineering are geology, mineral dressing and elementary courses in extractive metallurgy, in hydraulics, in mechanical engineering and in electrical engineering. Those are supporting subjects for the mining engineering studies which are concerned with ground control, systems engineering and administration.

A new mathematical system of analysis is available which is most useful to mining engineers. It is statistical analysis and is used to examine data for interpretation and significance. No engineer is more dependent on sample data than the mining engineer in ground control, systems engineering, administration, and valuation.

Ground Control

The pattern of the excavation in a mine is controlled by the geometry of the ore bodies, the parameters that determine the behaviour of the rocks that surround the openings, and the system designed to mine the ore. The design will be an optimum compromise among the controls. The geometrical design of the openings is based on rock mechanics.

Rock Mechanics: Rock Mechanics is the study of the rheology of geological materials with emphasis on those materials that, in practice, are regarded as rock rather than soil. The starting point of rock mechanics is mechanics of materials but there is a rapid divergence because rock is not an elastic substance, except under instantaneous loading. So far, it is best studied as a rheological material. Few of the precepts of mechanics of materials, or the theory of elasticity, are useful beyond instantaneous loading and relief.

The engineering material that most closely resembles rock is concrete. It is heterogenous and has rheological properties. A designer would not load it to its ultimate strength. The design of most mechanisms is based on loads that are predictable because they are assigned. The mining engineer has to accept a condition of triaxial primitive stress that in any site may have any orientation and magnitude for the components. Those attributes will not be stable. They are time-dependent. The excavations must accommodate the stress pattern. Only in the past few years have engineers successfully determined the orientation and measured the magnitudes of the stress components, even qualitatively. Progress is being made in mining research techniques to give precise measurements.

System Design

The high cost of labor and the disparity between the increase in the price indices of mineral products and those of labor and of commodities, coupled with the necessity to work lower grade deposits, has forced the use of elaborate and costly equipment, operated by highly paid skilled men. The result is that each operating unit must produce at its maximum capability.

The system must be in balance. That requires the engineer to know, from work study data, what a machine can do in an environment. The interdependence of units can be accommodated in an optimum manner, by the application of statistical and other mathematical studies of performance data. Similar techniques can improve maintenance of machines and travelways. Problems involving these applications of scientific principles belong in the curriculum.

Equipment Maintenance

The objective is to keep equipment at an optimum level of reliability and availability. This can be nicely engineered now. The result will lead to intelligent modifications of the equipment, to accommodate stresses not foreseen during the mechanical engineer's designing, and a predictable equipment use cost.

Administration

Safety and costs are the ultimate tests of any system. The ability to read a balance sheet is not enough for a mining engineer. He must know the cost statement and know the limitations of accountancy. The goal of cost accounting is to do away with the foreman's little black book.

Decision making and the use of electronic computers belong under this heading.

Economics

This was not listed among the fundamental subjects though it belongs there. It is included here as part of valuation studies. The value of a mineral property depends on the amount of mineral, the cost of making the finished product, the revenue from the sale, and how long that revenue will be available. The data gathered for the valuation estimate are sample data. The student should be prepared to give an objective statement of the degree of confidence that can be placed on the conclusions in the estimate. Someone has to use the estimate to make a decision.

Summary

The newly-graduated mining engineer cannot be well informed on all the facets that could control his career. Many are not even known when he graduates. The best that can be done, is to train him to never be complacent about an operation, and to put at his disposal the fundamental knowledge, that will enable him to produce a solution to problems of which his professors never dreamed. The problems will not be solved by a stroke of genius as one-man projects but by the co-ordination of a team of specialists, each as knowledgeable in his own field as a mining engineer must be in his field.

MAGNETIC INVERTERS

A REVIEW OF SWITCHING PROCESSES AND SOME NEW DEVELOPMENTS IN SELF-LOCKING CIRCUITS

C. H. R. Campling, M.E.I.C.
Associate Professor, Department of Electrical Engineering, Queen's University, Kingston

J. A. Bennett, A.M.E.I.C.
Lecturer, Department of Electrical Engineering, Queen's University, Kingston

D. H. O'Hara, A.M.E.I.C.
Junior Research Officer, Radio and Electrical Engineering Division, National Research Council, Ottawa

INVERTERS in which solid-state devices are used as switches are being used more and more frequently for the conversion of power from a d-c source to alternating form. Applications naturally occur in those situations where the available source of electric power is d-c, usually in the form of a battery. Land, marine and air transport are obvious fields in which such power conversion is often desirable or necessary. Polyphase inverters have been used to supply a-c motors in gyros for space vehicles. Portable electrical instruments and apparatus which require self-contained a-c power sources now commonly use inverters of this type. They are used in some automobiles. Flashgun units for photographic work are another everyday example of this sort of application in a consumer product. The reliability of the static form of inverter is one of its chief advantages. There are no moving parts. While transistors have been commonly used as switching devices higher power ratings are now realizable with switching devices of the silicon-controlled-rectifier type.

In an earlier paper[1] two of the authors presented a novel scheme for interlocking two or more transistor-magnetic inverters to form a polyphase inverter. The circuit had the merits of simplicity and versatility. No auxiliary timing devices were required. Any number of phases could be obtained with any desired phase-lock angle between any two of them. The term self-locking was used to describe this class of inverters. The present paper includes an account of some new circuit arrangements which increase the versatility of these self-locking inverters.

Switching in a Single-Phase Inverter

A basic form of the single-phase transistor-magnetic inverter is shown in Fig. 1. The essential features of its operation are well understood, although the details of the switching process which takes place in the very short interval when a transistor changes from its conducting state to its cutoff state are more obscure.

Very briefly, if we assume that one transistor, say the left one, has assumed its conducting role with the transformer core just coming out of its saturated state, then the emitter-collector voltage for this transistor is very small and in effect the d-c supply is connected across the left half of the transformer main winding. The rate of change of flux in the core will be

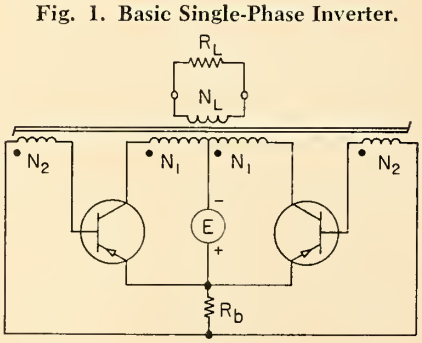
$$\frac{d\phi}{dt} = \frac{E}{N_1} \qquad (1)$$

and voltages will be induced in all other transformer windings proportional to this rate-of-change of flux. With the polarities indicated in Fig. 1 the voltages in the feedback windings of N_2 turns hold the left transistor in its conducting state and the right transistor off. This situation continues while the flux changes from its initial saturation level (say negative) through zero to saturation in the opposite (positive) direction. During this same interval the voltage applied to a load by the output winding will be constant and its value related to that of the d-c supply by the turns ratio N_L/N_1. When the transformer reaches positive saturation rapid switching occurs after which the transistors interchange roles, all transformer voltages take on opposite polarity, and the core flux begins to change back to its original negative saturation level. Thus the load voltage waveform is essentially rectangular. The frequency is given by

$$f = E/4N_1\phi_m \qquad (2)$$

where ϕ_m is the peak flux level reached in the cyclic operation of the core (normally the saturation flux). The transistors most of the time operate at low dissipation levels, corresponding either to very low voltage and a load-dependent current, or high voltage (double the d-c supply voltage) with very low current.

Fig. 1. Basic Single-Phase Inverter.



During the short switching intervals the transistors operate with much higher transient dissipation. If the frequency is increased, by design or by increasing the d-c supply voltage, these switching intervals may no longer be negligible compared with the period of oscillation. The average transistor dissipation will increase. Some knowledge of the switching process is therefore highly desirable and important.

An oscillogram of a typical "switching locus"—i.e., a plot of transistor collector-emitter voltage against collector current with time as a parameter—is shown in Fig. 2. While transistor operation during the switching interval is not adequately described by the steady-state common-emitter characteristics it is helpful nevertheless to correlate the switching locus with these characteristics. Typical sets for two identical transistors are shown in Fig. 3 with a sketch of the switching loci for the transistors superimposed. The points designated *A*, *B*, *C*, *D*, *E*, *F*, *G*, *H*, *K*, and *L* on the switching loci correlate with those designated by the same letters on the core hysteresis loop which is shown in Fig. 4. Unprimed capitals designate points for one transistor, primed capitals the corresponding points for the other transistor, and the lower-case letters the points on the hysteresis loop. Each letter corresponds to a particular instant of time in the cycle. Steady-state periodic operation is assumed.

At points *A* and *B* transistor *T*1 is conducting. While in this *ON* state the core flux changes from *a* to *b* in Fig. 4.

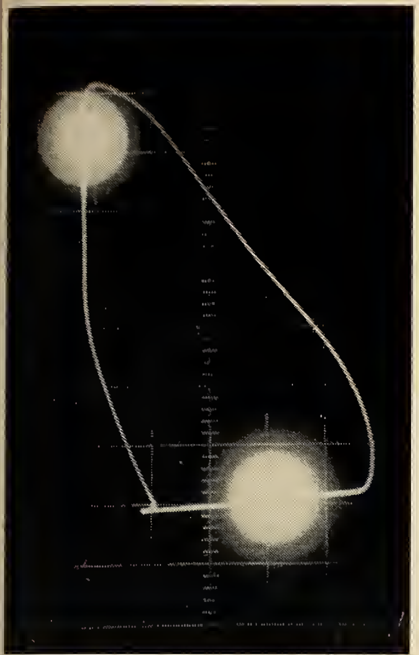
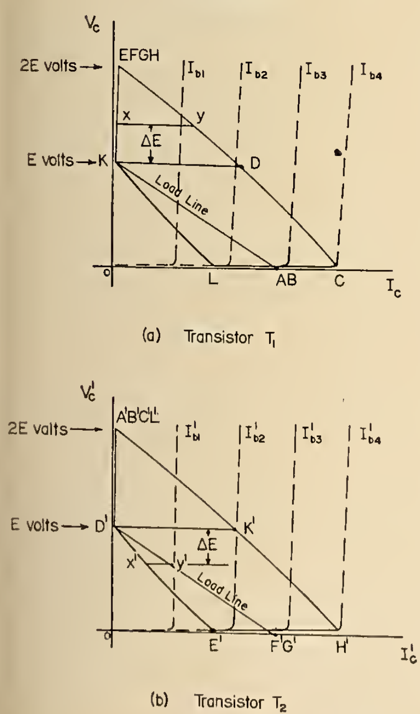


Fig. 2. Switching Locus for an Inverter Transistor — Collector-Emitter Voltage vs. Collector Current.

Since this condition continues for nearly half a cycle the corresponding point on the oscillogram in Fig. 2 is excessively bright. During the same half cycle transistor $T2$ is OFF and operates at points A' and B' on its switching locus. When the core saturates at b the magnetizing current increases rapidly. This increase is carried by transistor $T1$, but the increase which this transistor can handle is limited by the base drive

Fig. 3. Switching Loci for Inverter Transistors
(a) Transistor T_1
(b) Transistor T_2



current which is constant so long as the rate of change of flux and the corresponding feedback-winding voltage remain constant. If this base drive current is I_{b4} then the switching locus will proceed to point C. Thereafter the rate of change of core flux must decrease. Consequently the winding voltages decrease, and, if the transformer is idealized and has no leakage, the emitter-collector voltage for transistor $T1$ must increase and that for $T2$ must decrease. During the time interval between C and D this process continues. Transistor $T2$ has still not begun to conduct so that the increasing horizontal distance from the load line in Fig. 3(a) to the locus represents increasing magnetizing current for the core. This magnetizing current reaches its maximum at d, at which time the rate of change of core flux and the winding voltages are all zero. Transistor $T2$ now begins conducting at D'. Between D and E, while both transistors are conducting, the magnetizing current is the sum of the abscissa XY in Fig. 3(a) and the horizontal intercept $X'Y'$ in Fig. 3(b), these horizontal lines being displaced by equal voltage intercepts ΔE from the supply voltage level at K – D. Between E and F transistor $T1$ is OFF while transistor $T2$ continues to take over and the magnetizing current subsides to zero and reverses at f. Transistor $T2$ is now in the same situation which $T1$ occupied at the beginning of the cycle and the process continues as the core flux decreases from f to g.

This description of the switching process is idealized in some measure but it does account for the salient features. It is somewhat more complete than those which have been presented earlier.[2,3] The excellent correlation between this qualitative theory and the oscillographic result in Fig. 2 is attributable in part to the manner in which the inverter was loaded. The load was connected directly across the collectors of the two transistors and the effects of leakage inductance thereby minimized. A wide variety of switching loci shapes have been obtained for different conditions of loading. A routine example with load connected as indicated in Fig. 1 is shown in Fig. 5. Leakage effects account for the high collector voltage for the transistor as it goes off (upper right portion of the locus) and for the transient reversal of collector current in the transistor as it turns on (lower left portion of the locus). It is evident that the former effect increases the peak dissipation.

The Development of Polyphase Inverters

Transistor-magnetic inverters have been known since about 1955.[4,5] The invention first appeared in single-phase form, but the possibility of locking several inverters together to form a polyphase inverter quickly attracted

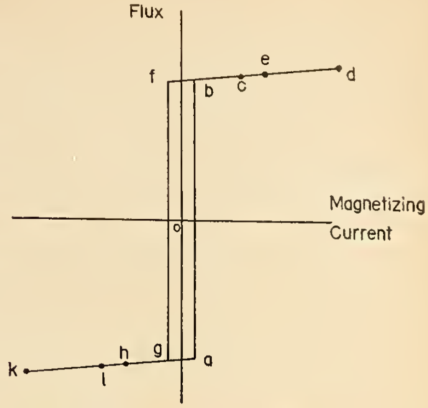


Fig. 4. Inverter Core Hysteresis Loop.

attention and a method of doing so appeared almost immediately.[6] This scheme, due to Milnes, was highly ingenious. Auxiliary magnetic cores were used in timing or locking circuits to fix the phase displacements between the several interlocked inverters. This scheme and others which have followed are to be distinguished from inversion methods which use a conventional oscillator, perhaps even a crystal-controlled oscillator, to determine by non-magnetic means the switching frequency of a group of transistor-magnetic switching units as well as the phase displacement between them. These inverters in which frequency and phase displacement are independent of magnetic core characteristics are of course competitive with those whose characteristics are intimately related to core and winding parameters. Each method has its inherent advantages and disadvantages. This paper is concerned with inverters whose control is all magnetic.

Fig. 5. Switching Locus — Effect of Magnetic Leakage — Collector-Emitter Voltage vs. Collector Current.

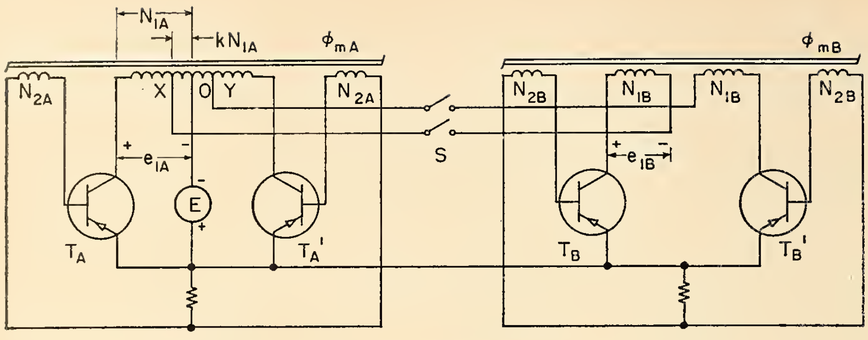


Fig. 6. Basic Self-Locking Inverter.

The first scheme in which phase displacement between a pair of locked inverters was made to depend upon the core-winding characteristics of the inverter transformers themselves, without having recourse to auxiliary phase-lock-control cores, was presented by Card in 1958.[7] This attractive circuit was limited however to two-phase output with the usual ninety-degree separation between phases. As with other magnetically-controlled inverters there was a master-slave relationship between the two phases. Unless the slave load was connected across the collectors of the slave transistors the voltage applied to it was not rectangular in form but stepped because the rate-of-change of the slave-core flux during the interval between successive slave - transistor switchings was characterized by two discrete values. That is, any winding on the slave core, including an output winding, was characterized by a voltage waveform which, over half a cycle, had two discrete voltage levels. It has been shown subsequently that it is quite possible to load the slave in such an inverter by means of an output winding on the slave core without interfering with the operation of the inverter, so long as the stepped waveform is compatible with load requirements and so long as the load so applied is kept within readily determinable limits.[1,8]

In 1960 the senior authors presented a generalized form of phase-locking in which magnetic phase-lock control was accomplished without auxiliary control cores.[1] This general scheme, in which the inverters were said to be self-locking, permits interlocking of any number of inverters with any desired set of phase-lock angles. The two-phase unit described by Card is a particular and practically important example of this technique.

The Self-Locking Principle

Since self-locking operation was described in detail in the original paper it will be reviewed here only briefly. The basic circuit is shown in Fig. 6. The master unit operates as described in the first section of this paper. It determines the operating frequency, which is given therefore by

$$f = E/4\, N_{1A}\phi_{mA} \qquad (3)$$

The slave is connected as shown to taps on the master main winding. The slave core in general will be characterized by a saturation flux ϕ_{mB} different from that of the master. Even if the cores are nominally identical the difference between ϕ_{mA} and ϕ_{mB} may be significant. The cores need not however be even nominally the same. As a result of the method of interconnection the voltage applied to a slave main winding while one of the slave transistors is conducting (say T_B in Fig. 6) changes abruptly when the master completes a half-cycle of operation from a magnitude $(1 - k)E$ to $(1 + k)E$, where k is a numeric called the tap ratio which describes the displacement of the taps X and Y on the master main winding from the centre tap. Taps X and Y in general need not be equidistant from the centre tap but for ordinary practical applications they are.

Steady-state waveforms are shown in Fig. 7. Switching occurs in either the master or slave whenever their respective cores fluxes reach the saturation level. Thus immediately after t_1 transistors T_A and T_B (Fig. 6) are both conducting. At t_2 the master core saturates and T_A cuts off while T_A' takes over conduction in the master. At this instant the voltage applied to the left main winding of the slave changes by an amount $2kE$. Subsequently, at time t_3, the slave core saturates and conduction in the slave transfers from T_B to T_B'.

For a given core with a winding of N turns the application of a steady voltage E to the winding when the core is saturated, say negatively, will, if the voltage is properly poled, cause the flux to change to the positive saturation level in a time τ given by

$$E\tau = 2\phi_m N \qquad (4)$$

Thus, just as the product $2\phi_m N$ is characteristic of the core-winding combination, so in the same sense is the product $E\tau$. It is referred to here as the volt-time area of the core and will be designated by the symbol λ commonly used for flux linkages.

The volt-time area of the master core will be designated λ_A. In one half period this change in flux linkages, from Fig. 7(a), is:

$$\lambda_A = ET/2 \qquad (5)$$

where $T = 1/f$ is the period of the master inverter. For the slave, whose characteristic volt-time area is λ_B, the half-period change in flux linkages is, from the geometry of the voltage waveform:

$$\lambda_B = E(1 - k)(1 - \alpha)T/2 + E(1 + k)\alpha T/2 \qquad (6)$$

where $\alpha T/2$ is the phase displacement in seconds. Therefore, from equations (5) and (6):

$$\lambda_B/\lambda_A = (1 - k)(1 - \alpha) + (1 + k)\alpha \qquad (7)$$

This ratio is called ρ, the linkage ratio. It depends upon the two core saturation fluxes and upon the turns N_{1A} and N_{1B} in their main windings. From equation (7) and the definition of ρ an equation for the phase displacement can be written.

$$\alpha = \frac{1}{2}\left(1 + \frac{\rho - 1}{k}\right) \qquad (8)$$

the place displacement θ in electrical degrees is related to the numerie α by

$$\theta = 180°\alpha \qquad (9)$$

The equation implies, in accordance with the observed facts, that, by judicious selection of the parameters ρ and k, any desired phase displacement between zero and 180 degrees can be obtained.

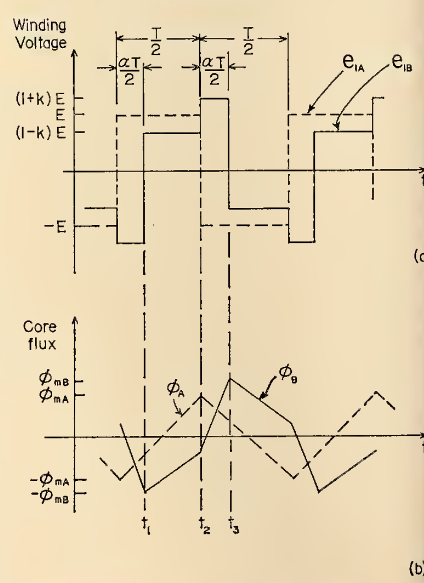
Phase-Locking Transients

The preceding analysis accounts only for the steady-state behaviour of the

Fig. 7. Steady-State Waveforms for Self-Locking Inverter

(a) Winding Voltages

(b) Core Fluxes



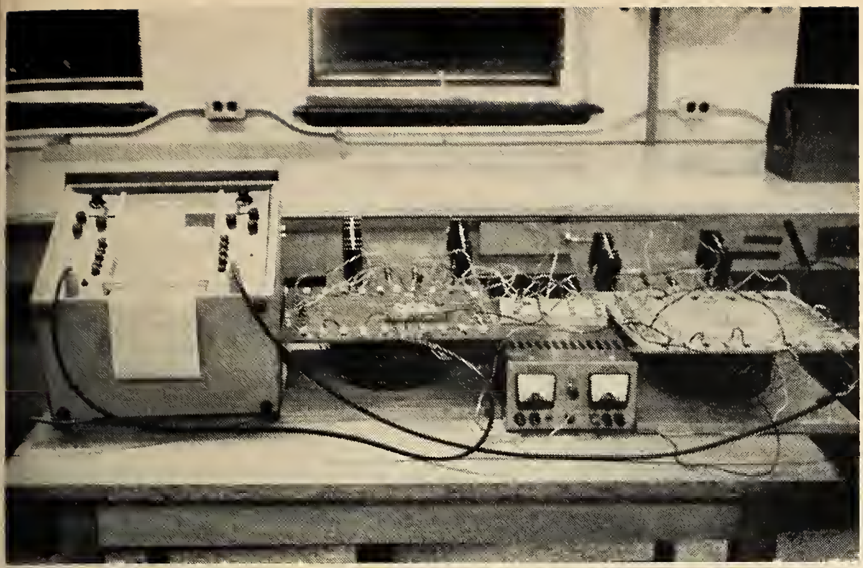


Fig. 8. Apparatus for Recording of Locking Transients.

locked inverters. This steady-state operation can be observed with ease in the laboratory. Phase-locking transients which occur when the slave is connected to the master are more difficult to analyse and to record experimentally. Complete analysis of this form of transient was presented in the authors' earlier paper[1] but was unsupported at that time by experimental evidence. Subsequent tests have confirmed the analysis.[9] The results of some of these tests are summarized and illustrated here, without repetition of the theory.

To gain information on these transients a pair of experimental inverters of rather large size were built for operation at frequencies in the range around one cycle per second. Written oscillographic records of locking transients extending over several cycles of operation were readily obtained in this way. A photograph of the apparatus is shown in Fig. 8.

Fig. 9. Locking Transient—Initial Lag Less than αT/2.

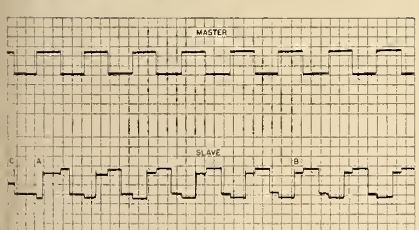
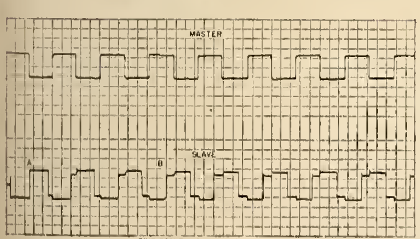


Fig. 10. Locking Transient—Initial Lag Greater Than αT/2.



In these experiments the flux in the slave core was preset initially to saturation level and then the slave was connected to the master, while the master was in operation, by closing switch S in Fig. 6. At very low test frequencies it is quite possible to time the switch closing manually with sufficient accuracy to initiate locking transients of various types.

Fig. 9 shows a transient in which the slave initially lags the master by less than the steady-state value. At C the slave was switched on. The sharp spike at this instant indicates that the slave transistor which initially conducted could not continue to do so because of the polarity of the saturating flux in the slave core. Immediate switching occurred in the slave. At A the slave lags the master by about 0.15 second. This amount increases progressively until at B the slave lags the steady-state value of about 0.425 second. There is no phase overshoot. The frequency in this oscillogram is about 0.784 cps.

Fig. 10 shows a locking transient in which the slave lags initially by more than the steady-state displacement. In fact, at A, after the slave has been in operation less than half a cycle it lags by almost 180 degrees. As in Fig. 9 the phase displacement steadily approaches its final value until at B the displacement is about 0.425 second.

A somewhat more interesting situation is shown in Fig. 11 where the initial conditions are so arranged that the slave leads the master immediately after the switch is closed. A lead phase displacement (as defined by the reference voltage polarities shown in Fig. 6) is unstable. At A in Fig. 11 the slave leads by about 0.40 second, which in this case is less than the design displacement of 0.425 second. This lead decreases progressively until, at B, it is so small that the master inverter switches twice between slave switchings at B and C. Thereafter the slave lags and approaches the steady displacement $\alpha T/2$. In Fig. 12 the situation differs from that in Fig. 11 in that the slave leads initially by somewhat more than $\alpha T/2$ seconds. In this case the lead increases progressively, approaching 180°, until at B and C a condition is reached where the master switches twice during a half cycle of slave operation. Thereafter again the slave lags and approaches its steady-state displacement.

These observations bear out in detail the theory presented earlier in mathematical form. The oscillogram of Fig. 11 in particular provides striking correlation with a unique aspect of the predicted behavior.

Some New Loading Methods

An apparent disadvantage of the self-locking inverter is that, unless the loads supplied by slave inverters are connected across the collectors of the slave transistors, the slave-load voltage waveform will be stepped rather than rectangular. Furthermore the drive-voltages applied to the bases of the slave transistors are stepped. The latter limitation requires that the tap ratio k, which governs the step height and which must be between zero and unity, be kept reasonably small. On the other hand a large k is desirable for rapid synchronizing. In addition the sensitivity of phase-lock angle to changes in the linkage ratio ρ is inversely proportional to k. From equation (8):

$$\frac{d\alpha}{d\rho} = \frac{1}{2k} \qquad (10)$$

Specifically this means that if larger tap

Fig. 11. Locking Transient—Initial Lead Less than αT/2.

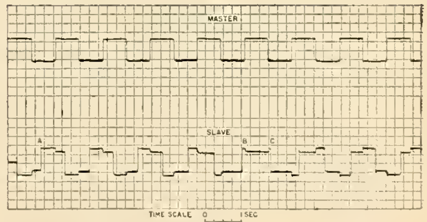
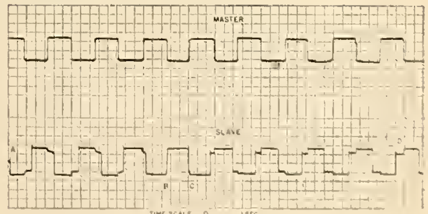


Fig. 12. Locking Transient—Initial Lead Greater Than αT/2.



ratios could be used the designer would have greater freedom to use nominally identical cores for master and slaves without having to pay as much attention to the fact that the saturation fluxes for these cores are likely to be different enough to affect significantly the phase-lock angles.

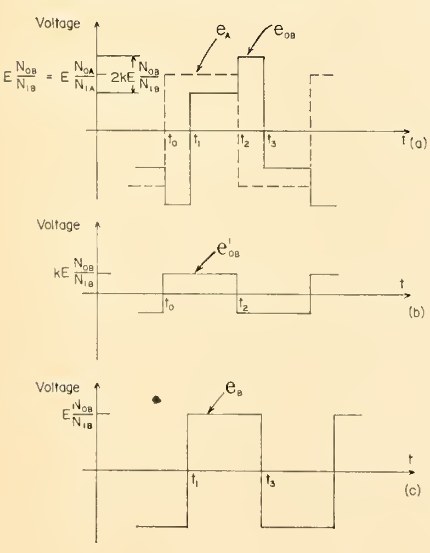
Rectangular voltage waveforms for driving slave loads as well as the bases of the slave transistors may be obtained either through the use of suitably proportioned auxiliary windings on the master core or by using an auxiliary transformer for each slave inverter.

The first of these schemes is shown in Fig. 13. In this figure, as in Fig. 6, only one slave is shown in the interest of simplicity. Three auxiliary windings—one of N_{OB}' turns and two of N_{2B}' turns are shown on the master core. The voltages induced in these windings are rectangular in form. The winding of N_{OB}' turns is designed to provide a voltage of the correct amplitude so that when connected as shown in series with the slave output winding of N_{OB} turns the output voltage from phase B will be rectangular. Similarly the auxiliary windings of N_{2B}' turns, when connected in series with the slave base-drive windings of N_{2B} turns, provide drive voltages for the bases of the slave transistors which are rectangular in form. Typical waveforms are shown in Fig. 14. It is evident that, for the desired result, the rectangular waveform from an auxiliary winding must have an amplitude equal to half the step height in the stepped waveform from the slave winding with which it is to be series connected.

In most applications it is desirable to have equal amplitude outputs from master and slave. Also, when identical

Fig. 14. Voltage Waveforms—Circuit of Fig. 13.

(a) Master and Slave Output Windings.
(b) Auxiliary Winding on Master Core.
(c) Output from Slave Phase.



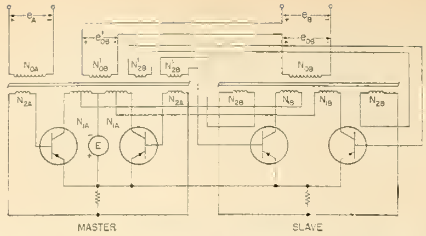


Fig. 13. Auxiliary Windings for Rectangular Output Waveform.

transistors are used throughout, equal-amplitude base-drive voltages should be provided. If the required no-load output-voltage amplitude is E_0 the number of turns required for the output winding on the master inverter is

$$N_{OA} = (E_0/E)N_{1A} \quad (11)$$

The base drive voltage will be EN_{2A}/N_{1A} volts. The turns N_{1B} for the slave main winding are determined from equation (8) in conjunction with equation (12) below.

$$\rho = \lambda_B/\lambda_A = N_{1B}\phi_{mB}/N_{1A}\phi_{mA} \quad (12)$$

In equation (8) any desired value can be assigned to the phase displacement α. With this circuit arrangement the designer has greater latitude in the selection of the tap positions. When identical cores are used $\phi_{mA} = \phi_{mB}$.

With N_{1A} and N_{1B} determined for specified frequency and phase-displacement and N_{OA} and N_{2A} on the basis of output-voltage and base-drive requirements, the slave winding N_{OB} and the master auxiliary winding N_{OB}' are wound in accordance with equations (13) and (14) below in order to achieve the result shown in Fig. 14.

$$N_{OB} = N_{OA}(N_{1B}/N_{1A}) \quad (13)$$

$$N_{OB}' = kN_{OA} \quad (14)$$

Similarly, for rectangular base-drive voltages in the slave inverter, equal in amplitude to those induced in the feedback windings (N_{2A} turns) on the master core, the slave feedback windings and the associated auxiliary windings on the master core should be designed in accordance with equations (15) and (16) below.

$$N_{2B} = N_{2A}(N_{1B}/N_{1A}) \quad (15)$$

$$N_{2B}' = kN_{2A} \quad (16)$$

The same result can be achieved, at the expense of using an auxiliary transformer with each slave unit, but with a reduction in the number of windings on both master and slave cores and attendant simplification of the problem of winding these cores, if the circuit arrangement of Fig. 15 is used. The auxiliary transformer must be so designed that it does not saturate appreciably. Its core material accordingly need not exhibit a sharp saturation characteristic.

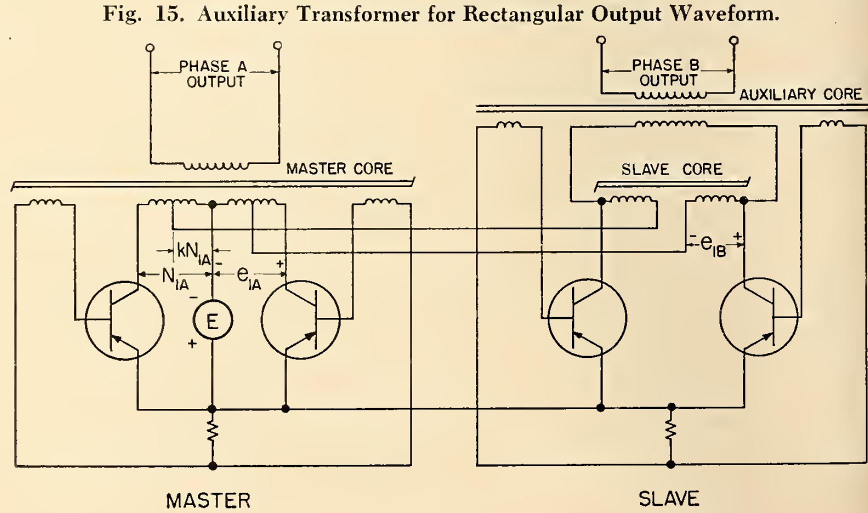
In this circuit advantage is taken of the fact that the collector-to-collector voltage waveform for the slave unit is rectangular. Hence all voltages derived from windings on the auxiliary transformer, whose primary is connected across the slave collectors, will have rectangular waveforms. Feedback windings and output winding for the slave are all wound on the auxiliary core. Experimentally it has proved possible to operate this inverter with tap ratios up to and including unity. In the extreme case, with $k = 1$, the voltage waveform for the slave main windings has a step height equal to twice the d-c supply voltage. Thus the voltages induced in the windings on the slave core have the form shown in Fig. 16 for e_{1B}, i.e. the winding voltage is zero for a fraction α of each half cycle.

In both of these loading arrangements the slave load currents produce no net magnetomotive force in the master core, nor do they load the transistors in the master inverter.

Sinusoidal Output Voltage

In some applications, though not in all, sinusoidal waveform or some reasonable approximation thereto may be required. Essentially these inverters are square-wave devices. When sinusoidal waveform is a requirement brute-force filtering may be used and has been although it is not basically a very attractive prospect.[10] One or two at-

Fig. 15. Auxiliary Transformer for Rectangular Output Waveform.



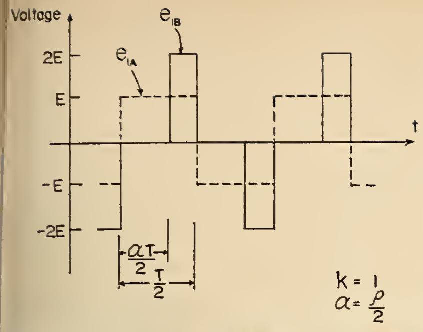


Fig. 16. Winding Voltage Waveforms—Circuit of Fig. 15 with k=1.

tempts have been made, with rather excessively complex circuitry, to synthesize sinusoidal waveforms.[11]

With the self-locking type of inverter a synthetic attack upon this problem is possible. Some extra complexity is inevitable but as compared with other alternatives the amount does not seem great. The principle used is similar to that employed in any alternator where distribution of the stator winding in slots around the air gap and series connection of the coils in groups permits the designer to realize an output voltage waveform which is much more sinusoidal than the voltage induced in any single coil.

As an example suppose a single-phase inverter is required whose output voltage is to be in some measure sinusoidal. One possibility (which as will be shown can be extended readily to three-phase operation) involves the use of a master and four slaves locked at 30°, 60°, 120° (or $-60°$ when the output polarity is reversed) and 150° (or $-30°$ when the output polarity is reversed). It will be assumed here that a slave arrangement is used which provides rectangular output-voltage waveform. Suppose that the master output is E volts in amplitude while those from the 30° and $-30°$ slaves are $(2/3)E$ and those from the 60° and $-60°$ slaves are $(1/3)E$. The waveforms for the master and slave outputs are shown in Fig. 17 together with the output voltage which results from a series connection of all output windings.

No great effort has been expended here to ensure that this result is the optimum approximation to a sinusoid which can be achieved with this number of slaves. The principle is evident however.

With one more slave locked 90° from the master it is possible by the use of combinations of windings from the six units to synthesize a waveform of the same shape shown in Fig. 17 for each of three phases. A block diagram of such a three-phase arrangement is shown in Fig. 18. Many other possibilities exist. More slaves could be used and output winding arrangements changed to get better approximations to sinusoidal waveform, but a price in terms of increased complexity would have to be paid. In the arrangement of Fig. 18 substantial improvement in output waveform is obtained at the expense of using only twice as many cores as would be required for even a simple square-wave three-phase inverter—and all cores in this circuit contribute to the total load rating of the inverter. For this reason the extra amount of iron and copper involved should not be weighed in the balance with an equivalent amount of iron and copper used in a filter system.

Conclusions

The switching process in a magnetic inverter involves relatively high transient dissipation in the transistors. Magnetic leakage in inverter transformers must be minimized to reduce the peak transient dissipation.

Phase locking transients conform to the pattern predicted earlier in the analysis of self-locking inverters.

Rectangular voltage waveforms are obtainable at any desired voltage level from the slave inverters in a polyphase self-locking inverter. Auxiliary windings on the master inverters may be used in a series connection with windings on the slave cores to achieve this result. Alternatively an auxiliary transformer can be used with each slave for the same purpose.

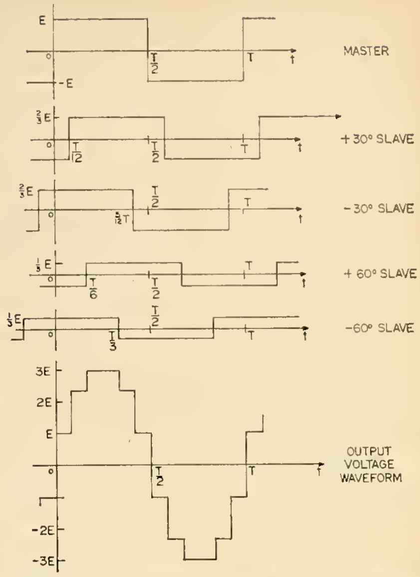


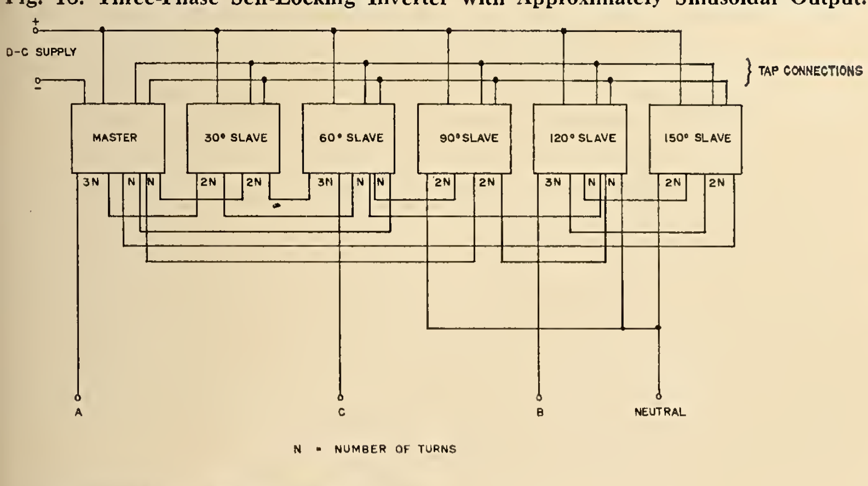
Fig. 17. Synthesis of Sinusoidal Output Waveform.

Stepped approximations to sinusoidal output-voltage waveform, for either single or polyphase loads, can be obtained from a suitably designed assembly of self-locking inverters.

Acknowledgment

Assistance from the National Research Council in the form of a grant has contributed to the support of the research reported in this paper. In addition Mr. O'Hara received assistance from the National Research Council in the form of a Bursary and subsequently a Studentship. All of this assistance is gratefully acknowledged.

Fig. 18. Three-Phase Self-Locking Inverter with Approximately Sinusoidal Output.



References

1. **Self-Locking Polyphase Transistor-Magnetic Inverters,** C. H. R. Campling, J. A. Bennett. AIEE Transactions, pt. I (Communication and Electronics), vol. 80, March, 1961, pp. 26-33.
2. **Operation of a Saturable-Core Square-Wave Oscillator,** Donald C. Mogen. 1956 National Conference on Aeronautical Electronics, May, 1956.
3. **Junction Transistor Electronics** (book) Richard B. Hurley. John Wiley and Sons, Inc., New York, N.Y., 1958, pp. 444-9.
4. **A New Self-Excited Square-Wave Transistor Power Oscillator,** George C. Uchrin, Wilfred O. Taylor. Proceedings, Institute of Radio Engineers, vol. 43, January, 1955, p. 99.
5. **A Switching Transistor D-C to A-C Converter having an Output Frequency Proportional to the D-C Input Voltage,** G. H. Royer. AIEE Transactions, pt. I (Communication and Electronics), vol. 74, July, 1955, pp. 322-6.
6. **Phase-Locking of Switching Transistor Converters for Polyphase Power Supplies,** A. G. Milnes. Ibid, vol. 74, November, 1955, pp. 587-92.
7. **Transistor-Oscillator Induction-Motor Drive,** W. H. Card. Ibid, vol. 77, September, 1958, pp. 531-35.
8. **Self-Locking Polyphase Transistor-Magnetic Inverters,** J. A. Bennett. M.Sc. Thesis, Queen's University, Kingston, Ontario, 1960.
9. **Transient Processes in Transistor-Magnetic Inverters,** D. H. O'Hara. M.Sc. Thesis, Queen's University, Kingston, Ontario, 1961.
10. **Solid-State Inverter Provides Reliable Emergency Power,** A. E. Maine. Canadian Electronics Engineering, vol. 4, May 1960, pp. 19-25.
11. **A High-Power D.C.—A.C. Invertor with Sinusoidal Output,** George Salters Electronic Engineering, vol. 33, September, 1961, pp. 586-91.

Discussion

WEAKNESSES OF THE THEORY OF PLASTIC DESIGN

A. HRENNIKOFF, M.E.I.C.

Professor of Civil Engineering,
University of British Columbia,
Vancouver.

The Engineering Journal, November 1961, page 57

Discussion by:

J. F. Baker, University of Cambridge
J. Heyman, University of Cambridge
M. R. Horne,
University of Manchester

Professor Hrennikoff has examined critically some aspects of structural design. From many points of view, his paper might be called "Weaknesses of the Theory of Elastic Design", since some of the detailed criticisms apply to any steel structure, independently of the way it was designed. We discuss below specific topics raised by Professor Hrennikoff, but wish first to make some more general remarks.

Professor Hrennikoff is particularly concerned with the effect of instability phenomena on plastic design, and he is right to be so concerned; but he ignores the fact that instability, whether of the structure as a whole or of individual members, is also one of the chief difficulties of elastic design.

Let us admit at once that the plastic theorems, which are so powerful in analysis and design, can be proved rigorously only for structures which remain stable. Upon making a plastic design, the designer must check carefully that his fundamental assumptions are not violated; for example, deflexions must remain small, plastic hinges must develop without local instability occurring, complete members must remain stable, and overall frame instability must not occur. These overriding design conditions apply to any structure, whether designed electrically or plastically.

If there is any danger of a design violating the conditions, modificattions must be made to the structure. In the worst case, a full analysis, elastic as well as plastic, must be made for the whole structure under all possible loading conditions, and allowing for the real state of the structure. The "real" condition of the structure differs from the "ideal" condition of the model structure assumed in analysis and design. Real conditions may include: an initial residual stress system, whether induced by welding, by inperfect fit-up, by settlement of supports, or whatever other cause; connections which are flexible to a greater or lesser degree; accidental imperfections in the members of the material, and, in short, all the ills that a structure is heir to.

All these remarks apply equally to elastic as well as to plastic design. It is the particular contribution of plastic theory that it has proved, for a wide range of structures, that many of the real conditions have negligible or zero effect on the carrying capacity of the structure. The elastic designer would in any case ignore most of the real conditions; his plastic colleague has justified his temerity.

It must be remembered that engineering design, however concrete the result, is essentially an abstract process. It is an exercise in mathematics applied to a model of the real structure. Accurate theory will predict accurately the behaviour of the model; whether or no the actual structure behaves like the model depends on the care with which the model is constructed. Now the models constructed by both elastic and plastic designers are essentially the same. If the plastic designer is worried by deflexions, or by instability, and decides to allow for these in the analysis, then so also will be the elastic designer. On the other hand, both may ignore a certain set of imperfections as being virtually certain not to affect the design.

The essential difference between elastic and plastic methods is that the latter will predict accurately an observable quantity for the structural model, i.e. the load factor against collapse. Elastic analysis, however, predicts no real quantity; it predicts stresses, and, as all tests on real structures have shown it predicts these badly. Further, plastic theory has demonstrated how the structural model should be constructed; for example, instead of guessing that the settlement of a support to a continuous beam will have negligible effect on the collapse load, it proves this. (This illustrates the simplicity of the plastic method; the elastic designer would reach an opposite conclusion, and much design time would be wasted in allowing for settlement of supports). Further yet, since plastic theory calculates a real quantity in the analysis of a structure, it is possible, virtually for the first time, to construct a rational design process.

Thus the designer can, by a direct plastic method, or by cut-and-try elastic methods, design the model of a given structure. It remains to decide whether this model will serve as the basis for the actual structure. This question is completely independent of the design method used, and many of Professor Hrennikoff's criticisms are really aspects of this question, and not criticisms of the plastic design method alone.

We do not claim that all the problems of plastic theory are solved. The state of the art is not yet advanced enough to predict accurately the behaviour of the model under all

EDITOR'S NOTE: In the January issue of the Engineering Journal the discussion and author's reply on Professor Hrennikoff's paper, "Weaknesses of the Theory of Plastic Design" were published. Included was an abbreviated version of the discussion by J. F. Baker. This created some confusion as Professor Hrennikoff's reply was based on the full discussion. This then, is the full discussion.

conditions, nor to answer fully the question as to whether the model is a permissible representation of the actual structure. The theory has been advancing step by step, and has been applied to more and more complex structures, from continuous beams to heavy plate girder grillages, from portal frames to multi-storey office blocks. At each stage in the advance, gaps in the theory have been disclosed, and attempts made to close these gaps. And, at each stage, experimental work has checked the theoretical predictions.

In the following detailed comments, the paragraph numbers refer to Professor Hrennikoff's original paper.

4. Elastic Instability of Beams

Concepts of buckling commonly held are developed from the idealised model of a pin-ended centrally loaded strut. In rigid-jointed structures loaded beyond the elastic limit, the first signs of buckling may occur at loads considerably less than the final collapse load.

The treatment of lateral instability of beams as given by Baker et al[1] is based, not on the first signs of buckling, but on the subsequent behaviour of a beam forming part of a rigid frame. If such a beam yields first at the ends, its lateral stability is scarcely affected compared with that deduced from elastic behaviour. If yield first occurs near the centre, the central length buckles laterally, but it is shown that this can only progress if the loads on the beam are simultaneously increased (pp. 242-6, ref. 1). This procedure is in accordance with the Shanley concept, here used not to derive the load at which buckling starts, but rather to follow the subsequent behaviour of the beam and thereby derive the true failure load. The purpose of the analysis is to establish limiting slenderness ratios such that the bending moment distribution assumed in rigid-plastic theory is approached during the post-buckling stage. During this stage, unloading of some fibres does occur, and it is for this reason that the behaviour of individual sections of the beam is derived by using the von Karman theory. The calculation of post-buckling behaviour is obviously extremely laborious, and the final equation (e.g. 12-39, p. 246, ref. 1) is justified empirically by considering numerical examples, as described in the text.

The author mentions the question of residual stresses. It may be shown that very high theoretical reductions are possible in the buckling loads of individual members as a result of residual stresses.[2] Such residual stresses may certainly exceed the 30% of the yield stress quoted by the author, and it is difficult to see how it can be argued that structures designed by plastic theory are affected by residual stresses, whereas elastically designed structures are immune. In fact, the existence of residual stresses brings into question the whole validity of elastic methods of design. If there exists in a structure a given intensity of residual stress, then a rational application of elastic design methods would require the inclusion of such stresses in the total calculated stress. The fact that this is not done destroys entirely the claim that elastic design methods are based on a rational procedure.

The fact that elastic methods of design are successful is entirely the result of the plastic behaviour of the actual structure. For the first time, as the result of advances in the theory of stability beyond the elastic limit, it is possible to make some general assessment of the effects of residual stresses on the failure loads of continuous structures[3]. It has been shown that if λ_F is the true failure load factor. λ_P the rigid plastic collapse load factor and λ_C the elastic critical load factor, the maximum possible effect of residual stresses is to decrease the failure load by $\dfrac{100\ \lambda_P}{2\lambda_P \times \lambda_C}$ %. This is in contrast to the much larger theoretically possible effects in single pin-ended members.[2] Since λ_C is, for all practical structures designed by the plastic theory, large compared with λ_P, the maximum reduction is small. Even this is an extreme condition, only realised by the most unfavourable distribution of residual stresses. While more study of the problem is required, it is certain that residual stresses are nothing like as serious in plasitc design as they would be in elastic design were their presence in the latter case honestly allowed for.

6 and 11 Column Theory and Effect of Overdesign of Beams.

The difficulties of designing columns for ultimate strength are readily admitted. After extensive work, the problem of column design even in elastic structures is still far from an adequate solution. Many problems present themselves, and where they are too complex to be solved explicitly in the design procedure, they have to be allowed for by adopting rules which may be shown to be safe on other grounds. The problem of apparent underdesign of the columns due to overdesign of the beams is a case in point.

The design procedure of assuming elastic behaviour in the columns and plastic behaviour in the beams is recognised as not being a fully rational solution of the problem. It has been proposed as a temporary solution on account of the difficulty of developing a column design method which allows properly for partially plastic behaviour. This lack of rationality is responsible for the apparent result that the overdesign of the member BC in Fig. 1 will result in the underdesign of the column. Since the strengthening of a member beyond its minimum section increases the overall stiffness of the structure, it is considered unlikely that this will result in a decrease of the ultimate strength. This tentative conclusion receives general theoretical support from recent work on frame instability.[4] According to this work, the failure load factor λ_F of a structure can be regarded as a function of the rigid-plastic load factor λ_P and the elastic critical load factor λ_C. An approximate lower bound for the failure load is then $\lambda_F\ \dfrac{\lambda_P\ \lambda_C}{\lambda_P + \lambda_C}$. An increase in either λ_P or λ_C leads to an increase in λ_F. Since the strengthening of a member must either increase or leave unchanged the values of both λ_P and λ_C, the result follows.

The above arguments are believed to justify the use of the minimum theoretical full plastic beam moments in calculating the moments in the columns. While it is impossible in tests to cover anything like all possible cases, laboratory observations show that all columns undergo some plastic deformation after first yield before final failure occurs. Such plastic deformation will enable a redistribution of bending moments in the overdesigned and therefore still largely elastic team, and the ultimate failure load of the structure will not be less than that assumed in the design method.

(Continued on page 92)

1. Baker, J. F., Horne, M. R., Heyman J. "The Steel Skeleton" Vol. II (1956) Chapter 12.
2. Horne, M. R. "The Influence of Residual Stresses on the Behaviour of Ductile Structures". Residual Stresses in Metals and Metal Construction, Reinhold, New York 1954.
3. Horne, M. R. "The Effect of Residual Stresses on the Behaviour of Continuous Structures" International Institute of Welding, Proceedings, Liege 1960.
4. Horne, M. R. "Instability and the Plastic Theory of Structures". Trans. Eng. Inst. Canada. Vol. 4 No. 2. 1960.

75th ANNIVERSARY ANNUAL GENERAL MEETING

"Many congratulations on the 75th Anniversary of the Engineering Institute of Canada. I send you all my very best wishes for a successful Annual Meeting and for the next twenty-five years until your Centenary celebrations.

Philip"

Superlative is the one adjective which describes the 75th Anniversary Annual Meeting of the Institute, held at the Queen Elizabeth Hotel, Montreal. The nearly 2,000 persons who registered witnessed or participated both in traditional ceremonies befitting a 75-year-old society, and an up-to-date technical program. Meetings of various committees stretched over a full seven days. Respect was paid to achievements of engineers and of the Institute since 1887, and even more enthusiastic attention was paid to the future.

Much of the credit for this outstanding success must be given to the members of the Montreal Annual Meeting Committee: Chairman, C. G. Kingsmill; Vice-Chairman, J. Benoit; Secretary, G. M. Boissonneault; Muriel's Room, Y. Hardy; Hotel Arrangements, B. Hesketh; Registration, R. J. Kane; Associate Activities, B. Lamarre; Budget and Finance, S. W. Pappius; Technical Papers and Publications, R. A. Phillips; Entertainment, A. Benoit; Publicity, G. H. Scruton; Transportation, W. B. White; Information and Reception, T. M. O'Neill; Plant Tours, L. Roy; Anniversary Show, M. D. Lester and members of their sub-committees.

Co-conveners of the Ladies' Committee were Mrs. Kingsmill and Mrs. Benoit. Mrs. Jean Dessaulles was Secretary.

Because of increasing interest in the technical and committee activities the meeting was scheduled over four days rather than three, although some groups began their meetings three days in advance of this.

The technical program was the largest and the strongest ever presented at an E.I.C. meeting. It incoporated some 70 papers in addition to a half-day panel discussion on engineering education, a symposium on management, and a symposium on heat transfer arranged by the National Research Council. The business meetings all reflected high enthusiasm for the future of the Institute.

At the luncheon on June 14, honors, prizes and awards were presented. This is described later in detail.

The social program also reached a new and enviable high in enjoyment and participation. The highlight was undoubtedly The 75th Anniversary Show held immediately after the Wednesday evening dinner during which representatives of sister societies and past Presidents of the E.I.C. were introduced.

The show was based on engineering in Canada since 1887. A narration and a fascinating series of historical slides tied together six fast-moving and expert dance sequences. Sound moving pictures were taken of the show for later distribution to Branches.

There were luncheons, small dinners for some groups, and the Annual Banquet which was addressed by Dr. John Tuzo Wilson, Head of the Institute of Earth Sciences at the University of Toronto. On the evening of the first official day of the meeting a reception and buffet supper was held at the Chalet atop Mount Royal, overlooking downtown Montreal. More than 1000 persons attended this affair.

The ladies' program included a demonstration and explanation of flower arranging, lunch at the Helene de Champlain Restaurant on St. Helen's Island in the St. Lawrence, a visit and tea at the CBC, and a "jet air robe show."

The first meeting of the 1962-63 Council.

The gavel, symbol of authority, is presented by retiring President Dr. B. G. Ballard to incoming President F. L. Lawton.

This informal picture was taken during the E.I.C. meeting on engineering education. From the left: Dr. Arthur Porter, Toronto; Dean Henri Gaudefroy, Montreal; Miss Elizabeth Finlaison, E.I.C. Headquarters; Mr. Lawton; and Lionel Boulet, Quebec City.

Four senior officers of the Institute are shown at the Annual General Meeting. From the left: G. N. Martin, a Vice-President and Chairman of the Finance Committee; incoming President F. L. Lawton; outgoing President Dr. B. G. Ballard; Treasurer E. B. Jubien.

ANNUAL MEETING OF COUNCIL

The Annual Meeting of Council was held June 10 with President Ballard in the chair. The meeting started at 7:00 p.m. and did not adjourn until nearly 1:00 a.m. Following are notes of a few highlights.

Publications Committee

Chairman R. A. Philips reported on plans for expediting and improving the publication of Transactions. A plan favored by the Publications Committee would involve immediate printing of all Transactions manuscripts accepted. These would be distributed as available to Members who had indicated an interest in the subject matter, and later would be bound into volumes. Council asked that this scheme be actively pursued.

Finance

Chairman G. N. Martin presented the report of the Finance Committee for 1961-62. CTO Chairman S. Sillitoe mentioned data processing equipment which now is being installed at Institute Headquarters. This equipment will prove helpful in tabulating information for a proposed membership Directory, and for other purposes.

Mr. Martin covered some discussions from the previous meeting of the Finance Committee at which the sale of the Headquarters building was investigated. He said a proposal which was before the Committee was not as straightforward as it had first appeared.

The Chairman explained that the increasing demands for services, coupled with the absence of a financial surplus from the Institute's publications, has made it necessary to approach the members to increase membership fees.

Committee on Technical Operations

Mr. Sillitoe reported on the largest technical program ever offered at an Annual Meeting. It consisted of 66 technical papers and three symposiums. He said CTO is gaining momentum in the acquisition of technical papers from the membership and through the Branches. There now are eight regional technical conferences planned for in the near future which have been publicized in the Engineering Journal.

Branch Operations

Chairman F. L. Lawton anticipated a vigorous meeting of his Committee the following day. He said Branch Model By-Laws have been developed by a subcommittee and are ready for submission to the full committee. Branch Model Accounts now are under active study.

Membership

Chairman E. D. Gray-Donald paid particular tribute to Miss Elsie Macgill of Toronto for her outstanding work on membership. Mr. Gray-Donald also commented upon the rapidly increasing membership in the Institute. The total is nearly 23,000.

Fellowship

This Committee's report, which dealt with how the new class of Fellow will be elected, was adopted with minor changes.

Library and House

Chairman R. H. Boyd reviewed the various discussions and decisions regarding the disposition of the E.I.C. Library. He traced these developments through the April 14 meeting of Council at which time it was decided to review the matter at the present meeting. Following lively discussion it was decided that the Council be asked by letter ballot to decide on the ultimate disposition of the Library.

Proposed Technical Societies Joint Council

Dr. Ballard reported on a meeting with the Presidents and General Secretaries of the Chemical Institute of Canada, the Canadian Institute of Mining and Metallurgy, the Canadian Association of Physicists, and the Engineering Institute of Canada. He said he regretted that the approach which was made was not received with great enthusiasm, mainly because of the still unanswered question of confederation. He felt that until this has been settled, not much more can be done in regard to the proposed Joint Council.

Vice-Presidents

It was resolved that the number of Vice-Presidents in Quebec be increased to four from two. Two would be assigned to Montreal, one to the eastern portion of the province including Quebec City and the North Shore, and one from the territory between Montreal and the Eastern portion, including the Eastern Townships, St. Maurice Valley and the North Shore.

It was resolved that in the Atlantic Provinces the number of Vice-Presidents be increased to two from one, the additional Vice-President being assigned to Newfoundland.

Education Conference

The General Secretary presented a brief report on the E.I.C. Conference on Engineering Education. He said the educators were pleased that this conference has again been made a part of the Institute's Annual Meeting procedure.

Confederation

Dr. Ballard presented a report of the Executive Committee on Confederation arising from a meeting with the Executive of the CCPE held in Montreal, June 9, 1962. Considerable discussion followed during which members expressed their views, and raised questions concerning the proposal.

COMMITTEE ON TECHNICAL OPERATIONS

At an important meeting of the Committee on Technical Operations, on June 11, the outgoing Chairman S. Sillitoe introduced his successor P. W. Gooch. This CTO Committee comprises the Chairman of the 14 Technical Divisions, and on this occasion attained a record roll call of 20.

Appointments were made of Technical Division Chairmen and some Vice-Chairmen, and the CTO program for the ensuing year was discussed, with special emphasis on the following matters:

1. Steps were urged to activate the Branches in the function of CTO. For this purpose all EIC Members must be properly categorized by fields of technical interest. Proper publication of branch news should be maintained.
2. In seeking or accepting technical papers, quality should be aimed at rather than quantity. Fewer papers might be planned for the Annual Meeting, with more time for presentation and discussion, and even with some plenary sessions.
3. Proper publication of papers should be aimed at, together with discussions and free from extraneous page matter in the Journal.
4. Branches should direct papers to CTO.
5. An Author's Guide should be made available soon.
6. French language technical papers should be encouraged.
7. A new Division was announced, called the Committee on Research Division, which is the fifteenth.
8. Consideration was given to proposing another Division to cover the field of Urban Transportation.

76th ANNUAL GENERAL MEETING

In President Ballard's opening remarks to the 76th Annual General Meeting of the Institute he noted that it had been an interesting year, and in many ways a difficult one.

"Our financial position is not as happy as we would like," Dr. Ballard said. "We budgeted for a balanced budget, but it proved to be too optimistic. Much of this is due to the fact that we relied in the past on profits from the Journal to discharge many of the operating expenses of the Institute and this is no longer possible. This is also true of many other organizations and commercial journals. We have had a number of discussions on some very important issues . . ."

Finance Committee

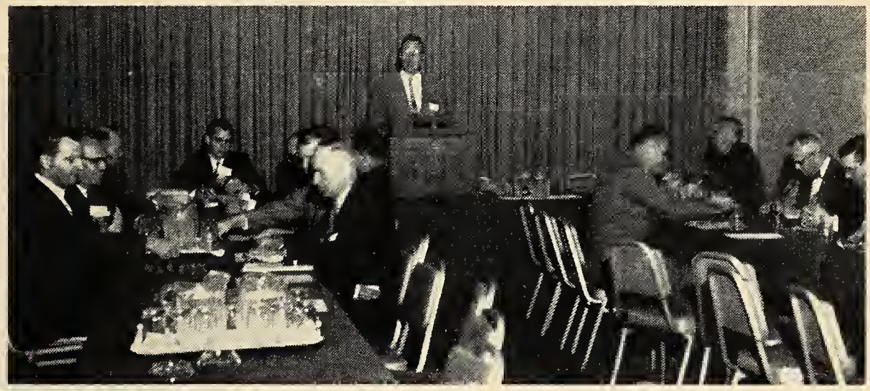
Chairman G. N. Martin said that in spite of his Committee's efforts, its reports was not a very happy one. The main reason, he explained, was that the publications no longer supplied a surplus from which other services could be supported. Additional revenue must be obtained from membership fees. He said that later this year the members will be asked to vote on a by-law change which would allow an increase in membership fees.

Dr. Ballard observed the need for a better method of publishing papers, as this is the life blood of a technical and learned society. It is not possible at present to publish all the good papers which are received. Methods are being adopted to reduce publication costs. Dr. Ballard said quality demands not only the publication of a paper, but also of its discussion.

This group constituted a small part of those attending a meeting of the Committee on Membership. From the left: General Guy Turner, Ottawa; H. C. Brown, Montreal; J. S. Dyer, Sarnia; E. D. Gray-Donald, Montreal; E. C. Luke, E.I.C. Headquarters; Chairman J. T. Fisher, Toronto; Lee Cameron, Halifax; Fred Perry, Calgary; I. B. Henderson, Winnipeg; R. H. B. McLaughlin, Fredericton; A. L. Morrison, Sherbrooke.

Taken during the first meeting of the 1962-63 Council this picture shows, from the left: Miss Lois McClintock; Garnet T. Page; F. L. Lawton; G. N. Martin; Professor J. B. Mantle.

This picture was taken during a meeting of the National Committee on Professional Development Programs. W. A. H. Filer of Hamilton is Chairman.



R. S. Eadie of Montreal receives his certificate of Honorary Membership in the Institute from Mr. Lawton.

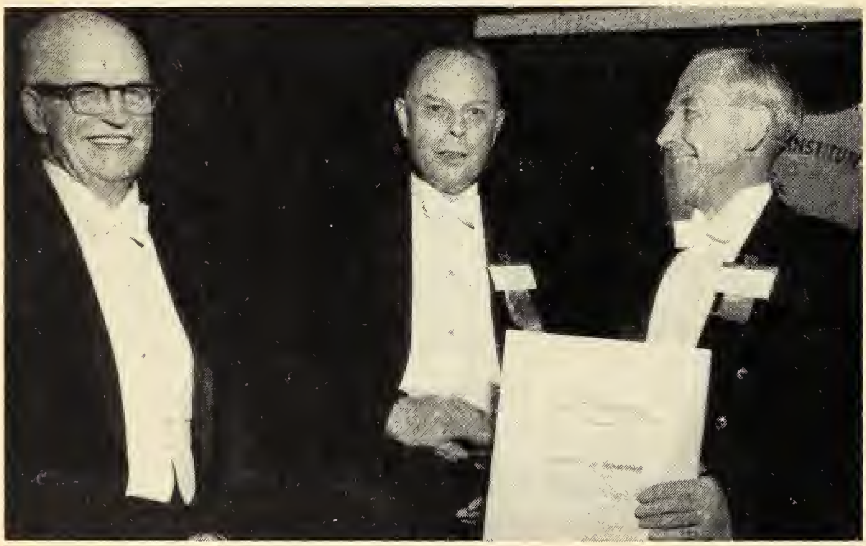
Dr. D. M. Stephens of Winnipeg receives his certificate of Honorary Membership from Mr. Lawton.

Normally the E.I.C. Student Prize and certificate is awarded during the year during a presidential visit. At the 75th Anniversary meeting though, a prize was presented by Mr. Lawton to S. E. Tavares of McGill University.

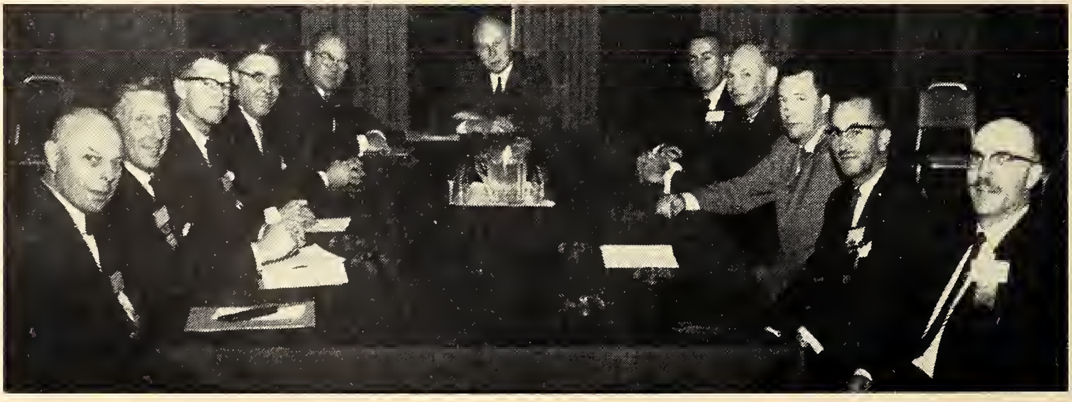
The Gzowski Medal "for the best paper on a civil engineering subject" was won by Rene A. C. Hauser and E. F. Pariset, both of Montreal. Mr. Pariset is shown receiving the medals from Mr. Lawton.

The R. A. Ross Medal for papers on electrical engineering subjects, was won by Dr. R. C. Langille of Ottawa. Mr. Lawton is making the presentation.

The Leonard Medal, "for papers on mining subjects" is presented to T. W. Wlodek of Ottawa by Mr. Lawton.



Dr. E. W. R. Steacie (right) President of the National Research Council, is congratulated by Dr. Ballard and by Dr. C. J. Mackenzie, former NRC President, on his receipt of his certificate of Honorary Membership in the Institute.



Shown are the Chairmen of a number of Standing and Special Committees of the Institute. From the left: Dr. Ballard; J. T. Fisher; R. Boucher; Mr. Lawton; Garnet T. Page, General Secretary; Mr. Gray-Donald; J. Hahn; R. A. Phillips; Professor William Bruce; G. N. Martin; Peter Gooch.

Treasurer's and Auditors' Report

In submitting his Treasurer's Report and that of the Official Auditors, Mr. Jubien said that some of the figures had already been commented upon by the President, and that it had been a particularly trying year.

Branch Operations

Chairman F. L. Lawton said very briefly, that the activities of Branches were analyzed on the basis of returns received, a report was compiled and some 18 recommendations were made which he believed were proving useful. He mentioned that the Committee, through its sub-committee on Model By-Laws and Model Branch Accounts was achieving practical success. Branch achievements Awards are being made this year for the first time and will be presented at the Honours and Awards Luncheon later in the week.

Membership Committee:

Chairman E. D. Gray-Donald presented the report in which he stated that the final figure on membership at the end of 1961 was 22,601. The figure now is close to 23,500. He paid tribute to the many members of the Committee, with particular emphasis on the outstanding work which Miss Elsie Macgill of Toronto has done and is continuing to do in obtaining new members. He said that he felt the obtaining of new and good members is a most important activity and that all members of the Institute should consider themselves as members of the Committee on Membership.

Committee on Technical Operations

Chairman S. Sillitoe, in presenting the report of this Committee, stated that the report had been written some time ago, when there were nine active divisions. Now, there are 12 active divisions and two more in process. This indicates the progress that has been made in the activities of the C.T.O. There is direct evidence of this also in the technical program which has been planned for the Annual Meeting, which includes 66 papers and three symposiums, and there are eight more regional conferences scheduled.

By-Law Amendments

After discussions, and with some amendments, it was decided that 10 proposed amendments to the By-Laws of the Institute be submitted to the members for their consideration by ballot.

Confederation

It was resolved that this General Meeting of the Engineering Institute of Canada assembled in Montreal authorize the Council of the E.I.C. or the Executive Committee of Council to proceed to ballot the membership on the Final Report of the Engineers Confederation Commission as published in the Engineering Journal, September, 1961. The ballot to be mailed to all members at the appropriate time to comply with the wishes of both E.I.C. and C.C.P.E., namely, that both memberships be balloted at the same time.

It was further resolved that the necessary explanatory notes be included with the ballot, bringing to the attention of the members the important issues to be considered, all in accordance with usual E.I.C. practice, and explain C.C.P.E. feeling on this.

Carried unanimously.

Vote of Thanks

Past President V. A. McKillop moved a vote of appreciation to Dr. Ballard for his services to the Institute during the past year. He said he was confident that all the members assembled must realize that Dr. Ballard brought to this office outstanding judgment and an ability to deal with the problems which arose with dignity and tolerance, and that he enhanced the reputation of the Institute in this country and in others.

STUDENT CONFERENCE

As in previous years, a student conference was held during the Annual General Meeting in Montreal. Forty delegates from all parts of Canada attended.

The delegates were welcomed by Dr. B. G. Ballard, President, F. L. Lawton, President-elect, C. Southmayd, last year's conference chairman and J. Hahn, Chairman of this year's conference. Dr. G. M. Dick, past President, then addressed the students. His subject was "Making the Most of Your Engineering Career". The General Secretary then explained the workings of the Institute and answered delegates' questions.

The main topics of discussion dealt with more student membership in the E.I.C., greater participation of student members in branch activities and closer branch-student co-operation. Other topics were also discussed by the delegates. These included the I.A.E.S.T.A., Canadian Overseas Volunteers and the Inter-College activities related to the E.I.C.

The discussions were summarized in the following resolutions:

a. Give support to the Canadian University Services overseas
b. Ask E.I.C student representatives to give headquarters reports on the past year's activities at their respective universities to be included in the advanced student conference notices
c. Ask Council to authorize the issue of a bi-yearly newsletter to be compiled by the students themselves to be mailed by headquarters to E.I.C. campus representatives
d. Ask Council to replace the tie clip, given as a free gift to joining students with the E.I.C. student lapel pin (if financially possible)

Student delegates also attended a comprehensive social program prepared by the delegates from Ecole Polytechnique and McGill University with the help of the Montreal Branch.

MEETING OF NEW COUNCIL

The new Council held a meeting on June 13, 1962. It was resolved that the President be empowered to appoint a small committee of four or five to prepare a statement of pros and cons and a statement of the Council's recommendation regarding the Report of the Engineers Confederation Committee for approval by the Executive Committee, and, if time permits, a full Council later on. It was resolved that:

Whereas this Council after due and prolonged study of the Report of the Engineers Confederation Commission is still in favour of unity for the profession; and

Whereas it is unable to recommend the adoption of the report because of the methods outlined in it for the implementation of such unity,

Be it resolved, therefore,

That Council ballot its membership, as agreed with the constituent member bodies of C.C.P.E. to do the same with its membership;

and That in the event of a failure to confederate as proposed, other avenues of co-operation be investigated with a view to developing acceptable and effective methods.

75TH ANNIVERSARY BANQUET

Reflections on Our 75th Anniversary

B. G. Ballard

Seventy-five years ago Saturday of next week, Royal assent was given to a charter carried through Parliament by Walter Shanly, himself a prominent engineer of the day, creating The Canadian Societ of Civil Engineers. It was the culmination of a series of discussions among Canadian engineers, particularly in Montreal, Ottawa and Toronto. The new Society had exactly 19 charter members, but by the time the charter was granted, the provisional Executive had examined and approved 288 members of all classes. The first President was Thomas C. Keefer, one of the famous Keefer brothers, and for the succeeding 30 years, the secretarial duties were discharged first by Professor H. T. Bovey of McGill, and later Professor C. H. McLeód, both men serving in spare time. I am certain that those gentlemen would be appalled at the volume of correspondence which flows from the Secretary's office today! The By-laws of the Society made it clear that Civil Engineering was interpreted to embrace all fields of engineering other than military.

From this humble beginning has emerged the great Institute to which we are doing honour this evening. In 1918, the charter was amended to change the name to The Engineering Institute of Canada so that it would be more descriptive of the broad range of engineering activities in Canada. The roster of early members includes all the great engineers of the country. We find Sir Sandford Fleming, Frank Shanly, who with his brother succeeded in completing the Hoosier Tunnel where other engineers had failed, Thomas C. Keefer, C. S. Gzowski, John Kennedy, Samuel Keefer, who had already built the world's longest suspension bridge of its day, C. E. W. Dodwell, Julian C. Smith, A. J. Grant, H. H. Vaughan, F. N. Gisborne, P. L. Pratley, H. G. Acres, F. A. Gaby,

C. Camsell, G. J. Desbarats, C. D. Howe, and a host of living engineers much too numerous to mention.

Since those early days, the Institute has enjoyed a long record of achievement. Its members have made important contributions to Canada's advancement, and they have distinguished themselves in several fields of engineering, both nationally and internationally. They have developed our roadways, our railways, our waterways, our power systems, and our mines. They have sponsored such organizations as the Canadian Standards Association and the present engineering registration bodies across the country.

During these past 75 years, engineers have made a greater impact on our way of life than any other single profession. In that time they have made possible the motor car, the airplane, electric power to home and industry, radio, television, radar, atomic energy, computers, and the development of a vast new group of materials to serve society even more effectively. They have produced new metals with characteristics which extend well beyond those of the earlier metals. They have developed new structural methods, and a whole new concept in machine design. They have taken full advantage of the scientists' findings, and have even contributed to scientific knowledge itself. It is significant that the first controlled fission was achieved by an engineer — Sir John Cockcroft. In the latter part of that period exceptional progress has been made. The electron was not discovered until nearly the beginning of the present century, vacuum tubes achieved popularity in the early 1920's, semi-conductor devices were only imperfectly understood until 1948, and were not employed successfully until well after that date. Diesel locomotives began to receive serious attention in the 1920's, electric phonographs, with the tremendous improvement in quality by comparison with the earlier mechanical types, followed shortly after. The trans-Atlantic telephone cable did not materialize until the 1950's. Sir James Chadwick discovered the neutron in 1932.

But the past is not important, except as a stepping stone to the future. What is in store for the next 75 years?

There are, of course, some general problems which are very obvious. The underprivileged nations will not be content for much longer to accept a lower standard of living than we enjoy on this continent, and the problems in achieving a higher standard on a world-wide scale are staggering. For example, Asia alone would require some 18 billion tons of iron, roughly three times that already produced. It would require 300 million tons of copper, 300 million tons of lead, 200 million tons of zinc, 30 million tons of tin, and huge quantities of other metals and non-metals. To produce these quantities would require a period of 100 years at our present rate of output, but shortages will develop, substitutes will be necessary, and engineering talent will be exercised to the limit.

The growth of world population presents particularly serious problems. At the present time, there is a net increase each week which would populate a city the size of Montreal, and unfortunately, most of this increase will not be housed in cities as comfortable or as attractive as Montreal. The sheer problem of providing food is overwhelming, particularly when it is considered that barely one sixth of the present world's population is well fed, and nearly half are victims of subnutrition, or malnutrition. If our present scale continues, there will be twice as many people to feed in the year 2000. Two thirds of the people of the earth live in areas that are suffering a shortage of fresh water. We in Canada are among the world's most fortunate in this respect.

Already our scientists are busily engaged in seeking new sources of food. The oceans have barely been tapped for such a resource. Genetics and heredity are the subject of intensive investigation to promote better plant life, and eliminate destructive bacteria or viruses, and generally improve our food supply sources as well as our own physical comfort. Extensive study has been devoted to the conversion of salt water to fresh water, and we can look forward to a vast application in this field.

Per capita use of energy is a relatively reliable yardstick of our standard of living. In Canada, electric energy consumption is increasing at the rate of 6% per annum, which means that it doubles every 12 years. In other words, within the next 12 years we will manufacture the equivalent of all our present electrical system with its plant, transmission lines and machines. And of course Asia and Africa will want the same benefits that we enjoy in the use of energy. It will be necessary to develop new methods of energy conversion to make the most effective use of energy resources. Atomic energy is only one facet of the solution, but it is a very important facet. There will be direct conversion from atomic energy to electric energy, rather than the present inefficient conversion through heat engines. We may expect to extract energy directly from a plasma created by atomic energy, and one stumbling-block which prevents the realization of this now is our inability to contain the plasma at the temperatures which prevail. No known material will withstand these temperatures, and we have endeavoured to employ a magnetic field for a basket, but it is a very leaky basket, and to date only transient success has been realized. There will be more direct conversion from heat to electricity in cells of the thermionic type and the thermoelectric type. Fuel cells permitting direct conversion from fuel to electricity will occupy a position of increasing importance. We will make greater use of our non-expendable resources, and more efficient use of our expendable resources.

It will become increasingly necessary to conserve the world's store of materials. New types of equipment will emerge. Devices will become smaller and more efficient. Recently, I had occasion to examine proposals for the generation of very intense magnetic fields here in Montreal, and to my surprise, I learned that the most promising commercial proposal was that of a magnet operating at near superconducting temperatures to reduce the electrical resistance and make possible a huge output with relatively small equipment. The saving was so significant that it would more than compensate for all the refrigerating apparatus necessary to produce these temperatures. But it is possible to lower temperatures even beyond those proposed for the above magnet, and electrical resistance in copper then disappears. Serious consideration is being given already to the development of transformers and power cables operating at superconducting temperatures.

Perhaps it is in the field of so-called "light engineering" in which the greatest changes will take place. A few days ago, a newspaper called me to inquire what possible use could be made of the results of our present space research. I replied that our space research was an effort to obtain information, rather than to find a practical application. Nevertheless, several possibilities were already obvious, entirely aside from the military significance of space vehicles. One very useful application will, I am certain, occur within the next few years. Satellites will be put into orbit which will enable us to communicate freely between any part of the earth and any other part, and what is particularly significant is that they will enable us to communicate at a more rapid rate. When we converse on the telephone, the rate of information flow is such that it can be carried with a circuit having a maximum frequency of from 3,000 to 5,000 c.p.s. If we want to hear good music, it must carry from 15,000 to 20,000 c.p.s. But if we want to carry a television program, the combined visual and audible information requires a frequency of four million c.p.s. We can now communicate freely between any part of the earth's surface and any other part at the lower frequencies, but to carry a television program, a much more sophisticated approach must be made, and the satellite appears to offer an answer, because the satellite can be arranged to "see" both points on the earth's surface simultaneously. It is probable that a message will be broadcast from one continent to the satellite, which will then rebroadcast to another continent, using for power, solar energy which the satellite converts to electric energy stored in batteries. The consequences of this are incalculable. It will mean that we will be able to see the way people live in other parts of the world, just as they will be able to see the way we live. Three years ago, it was my privilege to visit Russia, and I found the people were warm, friendly and hospitable. They are possessed of the same human instincts as ourselves, and I am convinced that if we got to know each other better, the arguments and conflicts which appear to confront us now would be resolved. Better communication of the type I am mentioning can achieve this.

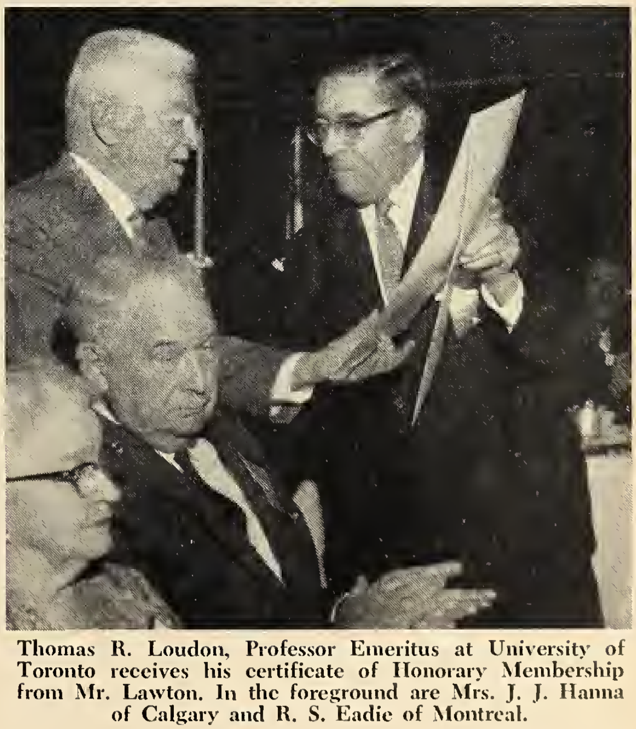
T. W. Eadie receives his Julian C. Smith Medal (1961) from Mr. Lawton. Looking on in the foreground is Mr. Eadie's brother, Robert, who was made an Honorary Member of the Institute.

Mr. Lawton presents the Julian C. Smith Medal (1961) to Frederic H. Peters.

Retiring President Dr. Ballard receives the traditional gift. The presentation is made by Dr. C. J. Mackenzie, former President of the National Research Council, while Mr. Lawton looks on.

Mr. Lawton and Dr. Ballard.

The Sir George Nelson Award "for a paper on the science of electrical engineering and its application, the author being a member of the Institute under 35 years of age" was won by K. H. Williamson of Winnipeg. Mr. Williamson was unable to attend the Meeting but his award was accepted on his behalf by L. A. Bateman of Winnipeg, shown receiving it from Mr. Lawton.



Thomas R. Loudon, Professor Emeritus at University of Toronto receives his certificate of Honorary Membership from Mr. Lawton. In the foreground are Mrs. J. J. Hanna of Calgary and R. S. Eadie of Montreal.

Satellites will also enable us to obtain better information for weather forecasting.

The next 75 years will see a tremendous increase in the part played by automatic machines and automatic control. Steel mills now produce a steel beam the dimensions of which are controlled not by a human operator, but by a perforated card inserted in a machine. This sort of control will be extended, and a revision in the product going down the production line will be achieved not by a manual readjustment of all the machines, but by simply inserting a new card or cards in the automatic control device.

A short time ago, I saw a machine winding the coils on an automotive generator. The operations of winding, soldering and machining were carried out solely by a mechanical man which had a limited mechanical brain, completely adequate to enable it to select the appropriate parts and to assemble them in the appropriate order. Automation also enabled the machine to inspect the finished product and reject those units which failed to measure up to the standards which had been set. It was an impressive operation, and yet I believe that it was poorly conceived. The mechanical man attempted to emulate its human counterpart, and to build a generator precisely as man would build it. I believe that our future machines will be designed so as to be more compatible with the capabilities of the mechanical man. Coils will be wound on salient poles rather than in slots, the number of electric connections will be reduced, and the commutator will be replaced by a solid state rectifier. The net result will be a cheaper and better unit. Undoubtedly, mechanization will change not only the methods of production, but also the design of the product itself.

And speaking of solid state devices — transistors, silicon controlled rectifiers, tunnel diodes, etc. — they will replace many of our vacuum tubes and many of our present rotating machines. They will make possible cheaper, smaller, lighter and more reliable electrical equipment.

The electronic computer is achieving greater and greater acceptance, and it is likely to do for the white collar worker what the automatic machine does for the blue collar worker. Each is equipped with a memory system and a facility for computation and assessment which approaches that of an individual, and in many respects exceeds it. It can perform all the ordinary mathematical functions, it can compare data, and make decisions based on the comparison.

The computer can, for example, play a fair amateur game of chess, but in checkers it displays a marked superiority over its creator. It learns by its own mistakes, and it is programmed to avoid a repetition of the mistake. It can read printed matter, and indeed can do so more reliably than a human. Each letter it reads is compared with every other letter of the alphabet, and the machine then makes an objective and quantitative assessment of the comparison. Even a smudged letter stands a better chance of being read accurately than in the case of the human operator. It will read different sizes of type. Arising out of this, it can read one language, and by storing in its memory the dictionaries and grammars of that language and any other language into which a translation is desired, it will translate, perhaps not as elegantly as a human translator, but acceptably. You may ask why this is not being used extensively now, and the reason is that, for once at least, the machine is more expensive than the human translator.

As Norbert Wiener has pointed out, "they (the machines) most definitely escape from the completely effective control of the man who has made them." Nor, it has been said, is there any comfort in the assertion that since man built the machine he will always be smarter or more capable than it is. On the contrary, we must derive our comfort from the fact that these machines require electricity for their operation, and we can always turn off the switch. This is not always possible with people.

The retrieval of information is another problem urgently demanding attention. The problem exists in all professions, but it is particularly acute in the engineering profession because the engineer must avail himself of the contributions of all scientists within his area of interest, as well as those of his fellow engineers. This is easy enough to state, but extremely difficult to realize. During the past twelve months, scientists and engineers are reputed to have published over 50 million pages. The magnitude of such numbers is always difficult to grasp, but 50 million pages would form a pile of paper over one mile high, and would fill the equivalent of 100,000 average length books. The difficulty of reviewing this vast volume of literature and extracting the items which may interest any one engineer is gigantic. Electronic retrieval machines will undoubtedly be called upon in the future. The engineer will tell the computer the field in which he is interested and the type of information he needs, and the computer will then proceed to review the extensive literature at incredible speed, and deliver the required data in a typewritten report. Already library sources are stored in this manner.

The application of such machines is endless. For example, the R. H. Macy Company is experimenting with the replacement of sales girls by electronic machines. Each machine is capable of dispensing 36 different items in 10 separate styles and sizes, and will accept in payment one-dollar and five-dollar bills, in addition to coins, and return the correct change, even rejecting counterfeit or spurious currency. It would, for example, reject Canadian currency, at least as long as the dollar is devaluated. Machines do not demand a coffee break, and do not quibble about hours of work. Admittedly, the aesthetic appeal may be somewhat lower, but even this point is disputed by some of our less romantic engineers.

It is announced that in France, electronic computers have been used experimentally to determine the guilt of people charged with law violations. The machine explores all law pertaining to the case, and assesses whether or not the evidence warrants conviction or acquittal. Perhaps few of us would want to rely on the impartiality of a machine in such cases, but the proponents insist that the machine is much more objective than any human court.

Similarly, I have seen an electronic unit which diagnosed disease in much the same way. The description of the patient's symptoms was fed into the machine which then proceeded to scrutinize every possible disease, and to identify the ailment consistent with the symptoms. In fact, the report on the performance of this machine reads as follows: "The development of procedures for medical diagnosis by machine is proceeding well. A completely automatic analysis of data can produce just as good a diagnosis of brain malfunction as that done by a highly trained doctor." In addition to such a diagnosis, it also assesses the reaction of the patient to various test procedures. In fact, it is suggested that a central machine could diagnose the ailments of patients in a large area simply by having adequate communication links between the local doctors and the machine.

During the past few weeks, Trans-Canada Air Lines has been installing electronic machines which will take care of reservations over their whole vast system. When completed, they will expedite the sale of space, and provide even better service. Perhaps I might venture a personal wish that they will make possible the elimination of the unending reconfirmation.

Computers are even taking over design functions, and the design of an electric motor which occupied a few days of my time as a junior engineer many years ago, is now completed in a few minutes by a computer, and even in this short interval, the computer explores more possible alternatives than I could afford to consider as a designer.

I have given a few examples of what is being done already, and what may be done in the future. But when the electronic computer is teamed with automatic control, the combination becomes a formidable competitor for manpower. Already machine tools are being controlled by computers, and information from drawings is stored in the computer memory system, and it controls the machine accordingly to produce the required item. In some cases, feedback control is employed to make certain that the finished product falls within the acceptable tolerances. It is certain that the same general acceptance of computers into our present commercial system will change the whole concept of management. Management will rely more and more on the collection of data by computers and the comparison which the computers will undertake. In fact, it is even possible that, in addition to changing production techniques and product design, as mentioned earlier, the computer may result in a revised language

John Young of Vancouver won the Robert W. Angus Medal (1961) for the "best paper on a mechanical engineering subject published in the Engineering Journal." As Mr. Young was unable to accept the Medal in person it was accepted from Mr. Lawton on his behalf by Mr. William Richmond of Vancouver.

Guy Laberge of Montreal receives the Ernest Marceau Prize from Mr. Lawton for "the best French language paper presented by an Associate of the Institute in the Province of Quebec.

F. L. Lawton, President 1962-63.

T. C. Higginson of Saint John receives the George McKinstry Dick Branch Achievement on behalf of the Northern New Brunswick Branch. Dr. Dick has just made the presentation while G. N. Martin looks on.

This year for the first time the George McKinstry Dick Branch Achievement Awards were presented. Vancouver Branch won the award for large Branches (more than 100 members). Being congratulated by Dr. Dick is C. F. Ripley of Vancouver. Beside Dr. Dick is Vice-President Martin.

Taken at a meeting of the ASME-EIC International Council, this picture shows, from the left: C. Southmayd, ASME; L. Sentance, EIC; W. H. Byrne, Past-President, ASME; Cliff Schumaker, President ASME; Garnet T. Page, General Secretary, EIC; Dr. B. G. Ballard, President EIC; Peter Gooch, EIC; Robert Nelsen, ASME; W. R. Sproule, ASME; O. B. Schier II, Secretary ASME.

The annual meeting of student representatives.

Joslyn Smith, second from the left, is receiving from Dr. Ballard replicas of the Julian C. Smith Medal. The son of Julian C. Smith accepted the replicas on behalf of the Smith family. Looking on are R. S. Eadie (left) and G. N. Martin.

Guest speaker at the Annual Banquet, Dr. John Tuzo Wilson.

This is a typical scene at an author's breakfast. S. Sillitoe, Chairman of the Committee on Technical Operations, is shown briefing the authors and chairmen on the presentation of papers and the conduct of sessions.

Mr. Lawton congratulates Past-President J. J. Hanna of Calgary on being awarded an Honorary Membership in the Institute.

system. Already it is causing at least some of us to think in a different scale of notation, and some of the alphabetical characters have been modified in shape to make them more compatible with the machine. It is common to talk of translation to machine language. Is it possible that we may become a trilingual country?

However, these innovations create new problems. Without adequate judgment, social problems of enormous range will develop. In fact, they are developing already. In theory, the computer and the machine should enable us to enjoy a fuller life with the same labour force, but in practice there are serious local dislocations. A greater demand is developing for more highly trained personnel to operate these more sophisticated machines, and a smaller demand for the less skilled personnel is evident. Indeed, it has been stated that "the shortage of (qualified) professional people is evidenced by the 60-hour and more work weeks of many professionals."

During the past ten years, despite an increase of 50 percent in the volume of telephone calls, the Bell Telephone System has increased its personnel by 10 percent. The U.S. Census Bureau employed 50 statisticians to undertake a tabulation in 1960 that had required 4,100 in 1950. The dislocation becomes more acute because we are interfering with the natural law of supply and demand. Cartels, restrictive trade agreements, tariffs and labour agreements upset the normal balance and impose artificial values which are overcome, but not corrected, through the use of machines.

It therefore becomes increasingly important that we as enginers accept our obligations and responsibilities for the consequences of the products of our minds. We cannot say that we are only engineers and that the manner in which our creations are employed is the responsibility of other people. I do not suggest that we must shoulder the whole burden of the world's future, but I do suggest that we must, in collaboration with the other professions, accept our proper share. Our knowledge of machines and their possibilities makes our participation particularly essential. We pride ourselves on being a profession of integrity. We boast that a machine will not function satisfactorily if it is not designed honestly, but I suggest that we should be very cautious that we are not deluding ourselves. All learned professions have become indispensable in modern society, and we must not take advantage of this fact. There is evidence of a decline in the respect in which society holds the professions. The engineering profession is perhaps least vulnerable in this respect, because it does not come into the same close contact with the general public as the other learned professions. It is significant that there is an agitation for socialized medicine, which may indicate public dissatisfaction with that profession. It is of interest to note that a professional man who is a candidate for election to the next federal Parliament chooses to present an image of himself as a "common man" rather than as a professional man. Personally, I want to be represented by an uncommon man who can bring the best possible brains to bear on the problems with which our federal government is confronted. If we do not enjoy the respect of society, we should ask ourselves why. We are an essential element of our vast economic system, and we must have a clear conscience regarding the integrity of our efforts. The public's image of the profession will not depend upon legislation, provincial or otherwise, but rather on the profession's contributions to society, and the integrity with which those contributions are made.

There is a fantastic future for engineers. The learned societies have an obligation to keep their members abreast of the latest developments, and also to assist us to assume our proper obligation with respect to the social problems which we will in a sense create. We will need a closer integration of all engineering disciplines, because few modern developments require only one. An atomic energy power plant, for example, requires the services of almost every type of engineer. We need also to establish close integration with other professions. The Engineering Institute of Canada has a unique opportunity to develop our profession and provide a service to Canada. Let us endeavour to achieve greater heights and a better world when we celebrate our 100th Anniversary.

PROFESSIONAL DEVELOPMENT

An extremely productive meeting was held of the National Committee on Professional Development Programs. W. A. H. Filer of Hamilton is Chairman.

Representatives from Calgary to Fredericton were on hand to discuss the program which offers courses in a wide variety of non-technical subjects. Programs now being offered by some Branches, and programs proposed by others received considerable attention. Mr. Henderson talked on the Engineers Council for Professional Development.

Dr. Ballard and the General Secretary discussed other phases of the program, and described what assistance was available through the Canadian Association on Adult Education.

The discussions and information are to be summarized for distribution to Branches represented at the meeting, and to other Branches which expressed interest in a Professional Development Program.

HONORS AND AWARDS

Five distinguished Canadians were awarded Honorary Memberships in the Institute and 12 others received different honors, prizes and awards for their contributions to engineering and its literature.

Receiving Honorary Memberships were:

Robert S. Eadie, Vice-President and Director of Engineering, Dominion Bridge Company Limited, Montreal;

John Jeffrey Hanna, Formerly Refinery Manager, Imperial Oil Limited, Calgary;

Thomas R. Loudon, Professor Emeritus, University of Toronto; Toronto;

Dr. E. W. R. Steacie, President, National Research Council of Canada; Ottawa;

Dr. D. M. Stephens, Chairman and General Manager, Manitoba Hydro-Electric Board, Winnipeg.

Other awards and their recipients:

Julian C. Smith Medal (1961) "for achievement in the development of Canada".

Thomas Wardrope Eadie, President, The Bell Telephone Company of Canada, Montreal, and Frederic Hathaway Peters, Past former Chief, Surveys and Mapping Bureau, Department of Mines and Resources, Ottawa.

The Czowski Medal (1961) "for the best paper of the medal year on a civil engineering subject. Rene A. C. Hauser and E. F. Pariset, both Montreal, for their paper entitled "Formation and Evolution of Ice Covers on Rivers."

The Leonard Medal (1961) "for papers on mining subjects" by T. W. Wlodek, Ottawa, for his paper entitled "The Double-Notched (V-V) Bar Tension-Bending Test."

The Plummer Medal (1961) "for papers on chemical and metallurgical subjects" by D. S. Scott, Associate Professor of Chemical Engineering, University of British Columbia, Vancouver, for his paper entitled "The Behaviour of Rarefied Gases."

The Duggan Medal and Prize (1961) "for the best paper dealing with the use of metals for structural and mechanical purposes" by A. Hrennikoff, Professor of Civil Engineering, University of British Columbia, Vancouver, for his paper entitled "Weaknesses in the Theory of Plastic Design."

The R. A. Ross Medal (1961) "for papers on electrical engineering subjects" by Dr. R. C. Langille, Superintendent, Electronics Laboratory, Defence Research Telecommunications Establishment, Ottawa, for his paper entitled "The DRB Topside Sounder Satellite."

The Robert W. Angus Medal (1961) "for the best paper on a mechanical engineering subject" by John Young, Assistant Professor, Faculty of Engineering, University of British Columbia, Vancouver, for his paper entitled "The Thermal Wedge Effect in Hydrodynamic Lubrication."

The Sir George Nelson Award (1961) "for a paper on the science of electrical engineering and its application" by K. H. Williamson, Manitoba Hydro, Winnipeg, for his paper entitled "Load Frequency Control System of the Manitoba Hydro-Electric Board."

The Canadian Lumbermen's Association prize (1961) by B. Madsen, Glulam Products Limited, New Westminster, B.C., for his paper entitled "Unique Design in Glulam." This prize is awarded for "a paper on the use of lumber or timber in construction; or the use of wood, including wood waste, in the manufacture of useful products; or in the development of methods of treating wood

to make it more resistive to destruction from decay, insects, marine organisms or fire; or in such other related subjects in wood utilization as may later be designed."

The Ernest Marceau Prize (1961) "for the best French-Language paper presented by an Associate of the Institute in the Province of Quebec" by Guy Laberge of Montreal for his paper entitled "Poutres en Acier Precontraint Travaillant en Composite avec la Dalle."

Branch Achievement Awards

It was appropriate that in this most successful of all Annual Meetings that the first presentations were made of the George McKinstry Dick Branch Achievement Awards. Dr. Dick was the 1960-61 President of the Institute.

The Award for large Branches (more than 100 members) went to Vancouver Branch. The handsome plaque was received on behalf of the Branch by C. F. Ripley. The award for small Branches was won by Northern New Brunswick Branch and was received on its behalf by T. C. Higginson.

COMMITTEE ON MEMBERSHIP

The largest meeting of the committee ever held took place on the afternoon of Thursday, June 14 with 21 members present.

Several problems of membership administration and procedure were dealt with first, and solutions were agreed upon and recommended to Council in every case. The proper role of the 75th Anniversary Special Membershop Committee was clarified and defined.

A review of the progress during the 12 months showed that the over-all increase in E.I.C. membership was nearly 7%. The meeting agreed that this reflects a very healthy and satisfactory condition. It is apparent now that the membership promotion drives at many of the Branches are beginning to show good results.

Taking a look at future activities, it was agreed that the four main points in the Committee's plan for 1962-63 should be:

a. The maintenance of full support for, and co-operation with, the Branch Membership Committees or Representatives.

b. Working with Headquarters, a continued search for new ways and means of encouraging membership growth.

c. The improvement and strengthening of the Institute's contacts with the engineering student bodies.

d. Continued attention to improving and streamlining our membership administrative procedures.

COMMITTEE ON PLANNING FOR THE FUTURE

On June 10th, 1962, the first meeting of the Committee on Planning for the Future was held. This Committee consists of G. M. Dick, Chairman, and the members as follows: Miss E. MacGill, Toronto; G. M. Boissonneault, Montreal; W. A. Capelle, Ottawa; H. Chaput, Ottawa; A. C. Davidson, Toronto; G. Demers, Quebec City; F. R. Denham, Toronto; E. D. Gray-Donald, Montreal; H. Gaudefroy, Montreal; D. A. Lamont, Peterborough, Ont.; H. Marshall, Halifax; G. N. Martin, Montreal; J. U. Moreau, Three Rivers, Que.; D. M. Myers, Vancouver; D. Stephens, Winnipeg; D. F. Tupper, Toronto.

Almost all the committee members were present and a considerable amount of interest and enthusiasm was displayed on this very important subject of future planning.

The terms of reference of the Committee on Planning for the Future are as follows:

> Establish a planning committee with well-balanced maturity and youth, knowledge and wisdom. The purpose of this planning committee would be the development of constructive future broad range planning for the Institute, for submission to, and deliberation and decision by, Council.

A number of members had previously submitted ideas as to the type of subject which should be discussed and these communications had been circulated among the membership and were eventually commented on by those present.

It was decided that the modus operandi of the committee should be as follows:

(1) Define the problems.

(2) Establish list of priories.

(3) Keep in mind the actual needs of the members.

(4) Have cognizance of the fact that "finances" seems to be a common denominator in most problems.

(5) Consider advanced training programs for Branch Chairmen and other Branch personnel probably one or two weekend seminars, held during the late summer.

(6) Keep in mind strength of The Institute is in the effectiveness of its Branches.

(7) Give proper consideration to what is required by public relations or otherwise to keep the name and purpose of the Institue sufficiently before the public.

(8) Consider a better form of "management" through regional controls, so that Vice Presidents and Councillors will be more effective in assuming responsibility for and promoting branch activities.

It would appear that, because of the geographical problem, that a considerable amount of this committee's work will have to be done by correspondence with a small sub-committee acting as a clearing house and circulating to the members the opinions of their confreres. The feed-back from such distribution would then be summarized by the sub-committee and proposed recommendations formed, which recommendations, in turn, would be sent to each member for his approval, or otherwise.

It appeared evident that immediate action should be taken on Item (8). Therefore this matter of regional operation will be given immediate attention in the hopes that a recommendation can be arrived at for submission to the President and Council at an early date.

ANNUAL BANQUET

Dr. Wilson, a prominent Canadian geophysicist, asked why engineers and seientists have had such a small part in the control and operation of society.

"It is certain that human civilization has patterns and that it operates," Dr. Wilson said. "In a sense then it can be thought of as an engine or machine which controls the pattern of our lives."

"In considering the enormous changes in this pattern which the development of this engine or society has introduced, it is convenient to consider three stages or cultures, those of the primitive savages, of the agricultural civilization and of the modern, technological societies.

"In the progress from one culture to the next it is clear that engineers and other technologists and scientists have played a major part and that the influence of the engineer and scientist in changing society is greater now than ever before. On the other hand, these men have played a rather minor part in the control and day-to-day operation of society.

". . . one may ask why engineers and scientists have so little part in the control and operation of society and whether it is desirable and possible to increase their influence."

CONFEDERATION

The problem of unity of the engineering profession of Canada and this proposal of the Engineers Confederation Commission received a great deal of attention by both the CCPE and the EIC during the past year.

The following is a chronological summary of the major activities and discussions immediately prior to and during the 1962 Annual General Meeting.

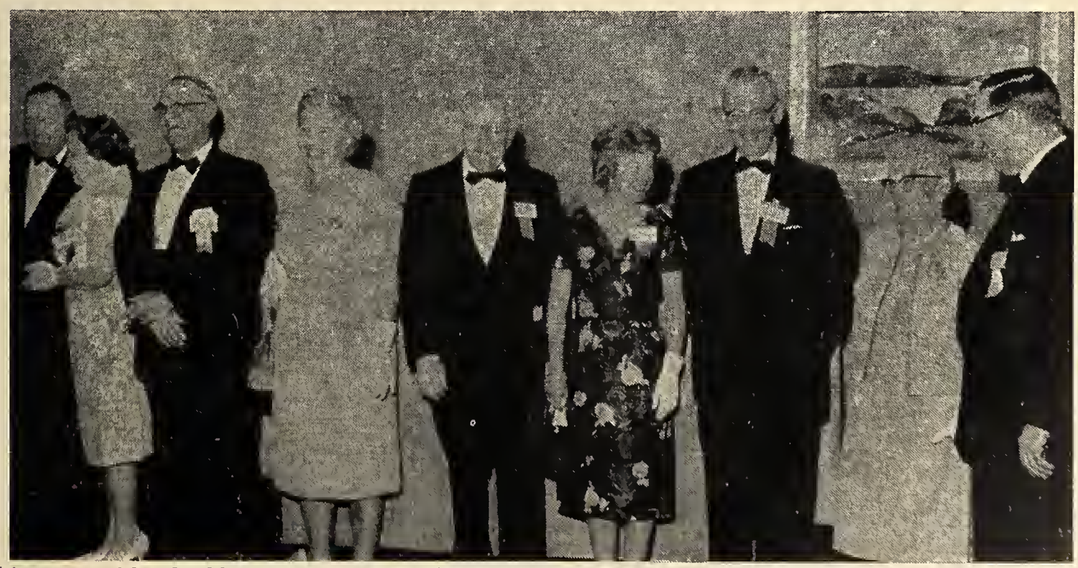
Meeting of Presidents of the Constituent Bodies of CCPE

In view of the evident complexity of the mater and the numerous obstacles encountered, a special meeting of the Presidents of the Provincial and territorial associations and the Corporation was called by the Canadian Council and held immediately prior to its annual meeting. The meeting was held May 8 in Quebec City.

The Presidents were requested to answer a series of eight questions which had been submitted to their respective Councils one month before the meeting. The replies tabled at the meeting indicated the following facts:

This is a candid picture of some head table guests at the 75th Anniversary Dinner. From the left: Dr. H. W. McKiel; Mrs. MacNab; Dr. J. B. Stirling; Mrs. Mackenzie; Mgr. Paul Gregoire; Dr. Ballard; Mrs. Stirling; Dr. C. J. Mackenzie; Mrs. Ballard; Dr. I. P. MacNab; Mrs. Vance.

Another picture of head table guests at the 75th Anniversary Dinner includes, from the left: Ross Dobbin; Dr. K. F. Tupper; Mrs. Lawton; V. A. McKillop; Mrs. Dick; Dr. D. M. Stephens; Mrs. Anson; Dr. J. A. Vance; Mrs. Heartz; Dr. H. W. McKiel.



This group of head table guests from the 75th Anniversary Dinner includes, from the left: Dr. R. E. Heartz; Mrs. Stephens; Dr. C. M. Anson; Mrs. McKillop; Mrs. J. J. Hanna; Mrs. Tupper; Dr. G. McK. Dick; Mrs. Hanna; Mr. Lawton.

a) Five Associations are not in complete agreement with the eight basic clauses proposed by the Joint Commitee on Confederation and used as basis for the Report of the Engineer's Confederation Commission.

b) Five Associations believe that the Commission's Report is in part inconsistent with the eight basic clauses, particularly clauses no. 2 and no. 8, and four of these Associations do not agree with the changes made by the Commission.

c) All Associations are prepared to submit to their membership a modified Confederation Report, but three Associations will do so only if the Engineering Institute of Canada agrees to do likewise.

Following considerable discussion, the meeting agreed to submit two major recommendations which were subsequently approved at the Annual Meeting of Canadian Council.

Decisions of Canadian Council of Professional Engineers, 1962 Annual Meeting Quebec City, May 9-11

The following motions were approved during the 1962 annual meeting and will become effective if ratified by the Council of the Provincial Associations.

1. RESOLVED that the Executive Committee of Canadian Council be instructed to continue negotiations with the Council of Engineering Institute of Canada on the basis of the Report of the Engineers' Confederation Commission and the essential and desirable changes to be made to this Report as requested or suggested by the members of Canadian Council and

RESOLVED that when these negotiations have reached the point where the Executive Committee of Canadian Council feels no further progress is being made, the members of Canadian Council agree to submit the Report of the Engineers' Confederation Commission (as it now stands or as subsequently revised by mutual agreement of the Executive Committee of Canadian Council and the Council of the Engineering Institute) to their members for a vote provided the E.I.C. Council is prepared to do the same.

This motion was carried unanimously.

2. RESOLVED that the Report of the Engineers' Confederation Commission be modified in such a way that membership in the proposed Institute being on a voluntary basis, provision be made for individual membership fees, which fees will be collected by the Provincial Associations for transmittal to the Institute, and that further provision be made for contributions to the proposed Institute by the Provincial Associations, these contributions to be comparable to those presently made to Canadian Council.

This motion was carried by majority vote.

3. RESOLVED that an endeavour be made by the Executive Committee of C.C.P.E. to negotiate with the Council of E.I.C. for acceptance of a change in the Report of the Engineers' Confederation Commission which would stipulate that branches or chapters are to report directly to the appropriate Provincial Association or Corporation with a provision that the Provincial Association or the Corporation may, if it so desires, authorize any branch under its jurisdiction to communicate directly with the National Body.

This motion was carried by majority vote.

4. RESOLVED that the Report of the Engineers' Confederation Commission be amended throughout to conform with that part of Clause 2 of the Joint Committee Report wherein it is stated that "full membership in the National Body shall be confined to members of the provincial and territorial Associations and Corporation of professional engineers."

This motion was carried by majority vote.

5. RESOLVED that the Executive Committee be empowerd to re-appoint or dissolve the Engineers' Confederation Commission when their present appointment terminates in October 1962.

This motion was carried unanimously.

Joint E.I.C.,— C.C.P.E. Meeting, Montreal, June 9

In accordance with the decisions of the Annual Meeting, a joint meeting of representatives of the Executive Committee of E.I.C. and of the Executive Committee of C.C.P.E. was held in Montreal on June 9th to explore the possibility of eliminating the serious differences of opinion between the two groups on important aspects of the Confederation proposal.

After considerable discussion it became evident that these differences could not be resolved and both groups agreed that it was not possible to modify the Report of the Engineers' Confederation Commission to make it reasonably acceptable to all groups concerned. It was further agreed to recommend to the two Councils that the membership be consulted by referendum on the basis of the existing proposal, each body reserving the right to comment on the Report as it saw fit.

Main Areas of Disagreement

The main points on which it appears impossible to reach agreement or compromise are as follows:

1. **Nature of Confederation.** — The interpretations given by each group to some of the eight basic clauses which served as a basis for the Confederation Report are substantially different. Consequently, approval in principal of these basic clauses simply indicated a desire on the part of all concerned for greater unity and strength within the profession the proposed method of achieving this objective being interpreted in different ways; the differences in interpretation unfortunately became evident only after the details had been worked out by the Commission and thoroughly studied the various Provincial and National Councils.

2. **Branches.** — The larger Provincial Associations insist that the Branches must come under Provincial jurisdiction while the E.I.C. believes it is essential for the successful operation of technical programmes that branches be under the jurisdiction of the National Body. Both feel that the proposed dual allegiance of the branches is impractical.

3. **Membership.** — The proposed substantial indirect compulsory contribution imposed on each individual engineer is not acceptable to some association Councils. Others feel that an assessment based on the entire membership of the Association is essential. The E.I.C. Council believes that a substantially higher fee would be required if membership and/or assessments are on a voluntary basis.

In addition it appears impossible to compromise on the proposed restrictions on membership.

4. **Annual fee or assessment.** — Several Association Councils believe that the proposed assessment of $12.50 per member is rather high while the E.I.C. Council is of the firm opinion that a minimum fee of $18.00 will be required to maintain its present level of technical services, assuming that this assessment would be paid on the basis of the entire membership of the Associations.

Decisions of E.I.C.

The Council of the Engineering Institute of Canada, at its 75th Annual General Meeting in Montreal, June 12, 1962, decided that the Institute will conduct a letter ballot of its voting membership to obtain an expression of their approval or not of the Final Report of The Engineers Confederation Commission, subject to the Institute receiving an assurance that each and every one of the eleven constituent associations and corporation of the C.C.P.E. will conduct letter ballots of their individual members on the same question, and all at the same time as the E.I.C. conducts its ballot.

It is clearly understood that the report referred to is the Final Report of the Engineers Confederation Commission as published in full in the September, 1961, issue of "The Engineering Journal", unchanged in any way.

It is also clearly understood that the Councils of the eleven constituent bodies of the C.C.P.E. and the Council of the E.I.C. are not obligated to recommend to their members that the terms of the report be approved; and that these Councils are free to advise their members of arguments for and against the terms of the report and to provide their members with the opinion of Council regarding the report.

4. This decision was approved unanimously at the Annual Meeting of the Institute held in Montreal on June 12, 1962.

Referendum

If the Councils of the Associations and the Corporation approve of a referendum of the basis of the Confederation Report a submitted by the Engineers' Confederation Commission, it is proposed to conduct such a referendum simultaneously amongst the members of the Associations and of the Engineering Institute of Canada before the end of the year.

THE ENGINEERING INSTITUTE OF CANADA

Officers 1962-63

PRESIDENT

F. L. Lawton, Montreal, Quebec

PAST PRESIDENTS

J. J. Hanna, Calgary
G. McK. Dick, Sherbrooke
B. G. Ballard, Ottawa

VICE-PRESIDENTS

Until May, 1963
F. M. Cazalet, Vancouver
G. N. Martin, Montreal

Until May, 1964
Paul E. Buss, Thorold
John Mantle, Saskatoon

George Humphries, London
John Waddington, Brockville
Gaetan Cote, Sherbrooke
Georges Demers, Quebec City
J. J. Rowan, Montreal
G. F. Bennett, Halifax
Stanley Carew, St. John's, Nfld.

TREASURER

A. W. Howard, Montreal

COUNCILLORS

Representing Sister Societies
E. D. Brown, Halifax
B. Chappell, Winnipeg
A. J. Groleau, Montreal
R. N. McManus, Edmonton
R. S. Sproule, Montreal

Until May, 1964
F. Alport, Orillia
A. G. Asplin, Niagara Falls
L. A. Bateman, Winnipeg
Marc Benoit, Montreal
W. A. Capelle, Ottawa
P. A. Dupuis, Quebec
F. F. Dyer, Sarnia
R. D. Hall, Lethbridge
R. J. Harvey, Montreal
W. M. Hogg, Sault Ste. Marie
W. L. Hutchison, Toronto
Redmond Kane, Montreal
D. A. Lamont, Peterborough
R. Ludwig, Saskatoon
H. A. Marshall, Halifax
T. A. Monti, Montreal
H. A. Mullins, Montreal
V. Palmer, Cape Breton
F. L. Perry, Calgary
J. Runge, Kitchener
A. Sandilands, Edmonton
W. M. Steeves, Moncton
J. H. Swerdfeger, Vancouver
A. M. Toye, Toronto
W. A. Wheten, Hamilton
G. B. Williams, Ottawa
B. T. Yates, Cornwall

Until May, 1963
V. A. Ainsworth, St. John's
Emil Bodmer, Baie Comeau
P. G. A. Brault, Montreal
H. B. Carter, Corner Brook
S. B. Cassidy, Fredericton
F. W. Catterall, Saskatoon
J. F. Chantler, Temiskaming
L. A. Coles, Summerside
A. C. Davidson, Toronto
J. E. Dykeman, Windsor
G. Flavell, Winnipeg
T. E. Flinn, Belleville
H. A. Gadd, Port Hope
H. R. Hatfield, Penticton
C. E. L. Hunt, Chalk River
W. B. Ibbotson, Surbury
D. M. Jenkins, London
L. C. Johnson, Victoria
C. P. Jones, Vancouver
S. D. Lash, Kingston
J. Longworth, Edmonton
C. C. Louttit, Arvida
D. B. McKillop, Ft. William
J. R. Menard, Rimouski
A. S. Mitchell, Lennoxville
J. U. Moreau, Three Rivers
D. S. Moyer, Port Credit
R. A. Phillips, Montreal
W. J. Phillips, Halifax
R. W. Pryer, Sept Iles
J. W. G. Scott, Saint John
G. B. Starr, Whitehorse
R. H. Wallace, Brockville
John S. Watt, Ottawa
L. Williams, Trail
J. W. Wilson, Amherst

Ex-Officio—Chairmen of Standing Committees, who are not otherwise members of Council

J. T. Fisher, Toronto
P. W. Gooch, Montreal
W. Bruce, Montreal
E. D. Gray-Donald, Montreal

GENERAL SECRETARY

Garnet T. Page

HEADQUARTERS

2050 Mansfield Street, Montreal, Que.

OFFICERS OF THE BRANCHES

AMHERST
Chairman, W. D. Hagen, M.E.I.C., c/o Robb Engineering Works Ltd., Amherst, N.S.
Secretary-Treasurer, Joseph F. LeJeune, A.M.E.I.C., 109 Church Street, Amherst, N.S.

BAIE COMEAU
Chairman, Louis Tellier, M.E.I.C., P.O. Box 575, Baie Comeau, Que.
Secretary, Douglas G. Manzer, M.E.I.C., Box 207, Site 7, R.R. 1, Hauterive, Que.

BELLEVILLE
Chairman, W. J. N. Throop, M.E.I.C., P.O. Box 305, 235 Herchimer Avenue, Belleville, Ont.
Secretary-Treasurer, E. H. Gilroy, A.M.E.I.C., 45 Prince of Wales Drive, Belleville, Ont.

BORDER CITES
Chairman, R. H. Darke, M.E.I.C., 3281 Everts Avenue, Windsor, Ont.
Secretary, R. L. Kennedy, M.E.I.C., 244 Esdras Place, Windsor, Ont.

BRAMPTON
Chairman, Clifford L. Moon, M.E.I.C., 26 Gregory Street, Brampton, Ont.
Secretary-Treasurer, Bruce E. Wilson, M.E.I.C., 23 Hadrina Crescent, Brampton, Ont.

BROCKVILLE
Chairman, J. B. Moriarty, M.E.I.C., Benson Avenue, Cardinal, Ont.
Secretary-Treasurer, P. Stata, A.M.E.I.C., 25 Murray Street, Brockville, Ont.

CALGARY
Chairman, A. F. D. Short, M.E.I.C., 1211 - 38th Avenue S.W., Calgary, Alberta.
Secretary, Ralph S. White, M.E.I.C., 660 - 97th Avenue S.E., Calgary, Alberta.

CAPE BRETON
Chairman, H. C. Maitland, M.E.I.C., 39 Cross Street, Sydney, N.S.
Secretary, Lloyd R. Boutilier, M.E.I.C., 29 Royal Avenue, Sydney, N.S.

CENTRAL BRITISH COLUMBIA
Chairman, Brian S. Harvey, M.E.I.C., 1944 Abbott Street, Kelowna, B.C.
Secretary-Treasurer, R. J. Talbot, M.E.I.C., 2008 Valleyview Drive, R.R. 2, Kamloops, B.C.

CHALK RIVER
Chairman, R. Haliburton, M.E.I.C., 4 Cabot Place, Box 696, Deep River, Ontario.
Secretary, L. L. Robbins, A.M.E.I.C., 31 Glendale Ave., Deep River, Ontario.

CORNER BROOK
Chairman, H. B. Carter, M.E.I.C., 29 West Valley Road, Corner Brook, Newfoundland.
Secretary, E. R. Skanes, M.E.I.C., c/o Bowater's Nfld. Pulp & Paper Mills, Corner Brook, Nfld.

CORNWALL
Chairman, G. B. Stidwell, M.E.I.C., 416 Third Street W., Cornwall, Ont.
Secretary-Treasurer, P. L. Laprise, M.E.I.C., c/o Cornwall Street Railway Light & Power Co., 16 Second Street East, Cornwall, Ont.

EASTERN TOWNSHIPS
Chairman, Jacques Brisson, M.E.I.C., c/o Brisson & Lantendresse, P.O. Box 624, Sherbrooke, Que.
Secretary-Treasurer, P. E. Brunelle, A.M.E.I.C., 441 Blvd. Jacques Cartier N., Sherbrooke, Que.

EDMONTON
Chairman, B. A. Ellis, M.E.I.C., 11239 - 83rd Street, Edmonton, Alta.
Secretary-Treasurer, D. B. Smith, A.M.E.I.C., 14003 - 84th Avenue, Edmonton, Alta.

FREDERICTON
Chairman, R. H. B. McLaughlin, M.E.I.C., Dept. of Civil Engineering, U. of New Brunswick, Fredericton, N.B.
Secretary, W. B. Cuthbertson, M.E.I.C., 173 Parkhurst Drive, Fredericton, N.B.

HALIFAX
Chairman, G. F. Vail, M.E.I.C., 94 Morningside, Halifax, N.S.
Secretary-Treasurer, D. H. Waller, M.E.I.C., P.O. Box 33, Halifax, N.S.

HAMILTON
Chairman, W. A. H. Filer, M.E.I.C., 10 James Street N., Hamilton, Ont.
Secretary-Treasurer, K. R. Crean, M.E.I.C., Room 515, 42 James Street N., Hamilton, Ont.

HURONIA
Chairman, Frederick Alport, M.E.I.C., 65 Peter Street North, Orillia, Ont.
Secretary-Treasurer, Louis Morgante, M.E.I.C., 36 Borland Street W., Orillia, Ont.

KINGSTON
Chairman, L. C. Miller, M.E.I.C., 4911 Albert Street, Kingston, Ont.
Secretary-Treasurer, F. J. Parcher, M.E.I.C., 168 Avenue Road, Kingston, Ont.

KITCHENER
Chairman, Roy Dahmer, M.E.I.C., 778 Union Street, Kitchener, Ont.
Secretary-Treasurer, E. H. Wilson, 720 Avondale Avenue, Kitchener, Ont.

KOOTENAY
Chairman, Stanley Nixon, M.E.I.C., 1530 Tulip Street, Trail, B.C.
Secretary, G. W. Downie, M.E.I.C., Box 646, Rossland, B.C.

LAKEHEAD
Chairman, E. B. Ashton, M.E.I.C., 439 Heather Crescent, Fort William, Ontario.
Secretary, L. E. Hardman, M.E.I.C., 172 Ibbottson St., Port Arthur, Ontario.

LETHBRIDGE
Chairman, R. W. Jones, M.E.I.C., c/o Oland Construction Ltd., 930 - 3rd Avenue N., Lethbridge, Alta.
Secretary-Treasurer, R. F. Smith, M.E.I.C., 2113 - 14th Avenue S., Lethbridge, Alta.

LONDON
Chairman, G. T. Fenwick, M.E.I.C., c/o Unifin Tube Co., P.O. Box 7, Clarke Sideroad, London, Ont.
Secretary-Treasurer, E. Oddleifson, M.E.I.C., Hydro Electric Power Commission of Ontario, 340 Wellington Street, London, Ont.

LOWER ST. LAWRENCE
Chairman, L. P. Dancose, M.E.I.C., The Canada Gulf & Term. Railway Co., Mont-Joli, Que.
Secretary-Treasurer, Raymond Guerin, A.M.E.I.C., 1509 de la Sapiniere Street, Rimouski, Que.

MONCTON
Chairman, L. R. Wadlyn, M.E.I.C., 115 Bessborough Ave., Moncton, N.B.
Secretary-Treasurer, V. C. Blackett, M.E.I.C., 97 MacBeath Ave., Moncton, N.B.

MONTREAL
Chairman, C. Grange Kingsmill, M.E.I.C., c/o Angus Robertson Ltd., 5035 Western Ave., Montreal, Que.
Secretary-Treasurer, Albert Deschamps, M.E.I.C., 6931 Cote des Neiges, Montreal 26, Que.

NEWFOUNDLAND
Chairman, A. M. Butt, M.E.I.C., 8 Cork Place, St. John's, Newfoundland.
Secretary, A. E. O'Reilly, M.E.I.C., Newfoundland Light & Power Co. Ltd., P.O. Box 976, St. John's, Nfld.

NIAGARA PENINSULA
Chairman, R. D. MacKimmie, M.E.I.C., 9 Sunnyside Drive, R.R. 5, St. Catharines, Ont.
Secretary, B. H. Chick, M.E.I.C., 24 Brisbane Glen, St. Catharines, Ont.

NIPISSING & UPPER OTTAWA
Chairman, R. A. Booy, M.E.I.C., Box 1, Temiskaming, Que.
Secretary-Treasurer, Norman L. Ede, A.M.E.I.C., c/o Canadian International Paper Co., Temiskaming, Que.

NORTH EASTERN ONTARIO
Chairman, I. M. Foster, M.E.I.C., 6 Drury Street, Kapuskasing, Ont.
Secretary-Treasurer, John W. Shipman, M.E.I.C., 64 Dominion Street, Kapuskasing, Ont.

NORTHERN NEW BRUNSWICK
Chairman, G. J. Melanson, M.E.I.C., P.O. Box 781, Dalhousie, N.B.
Secretary-Treasurer, Rex J. Edwards, A.M.E.I.C., Chaleur Inn, 660 Montgomery Street, Dalhousie, N.B.

NORTHERN NOVA SCOTIA
Chairman, J. E. Clarke, M.E.I.C., 38 Maple Avenue, New Glasgow, N.S.
Secretary, Murray C. Wolfe, M.E.I.C., P.O. Box 964, Stellarton, N.S.

NORTH SHORE LOWER ST. LAWRENCE
Chairman, B. A. Kelly, M.E.I.C., P.O. Box 188, Shelter Bay, Que.
Secretary, George Jardine, M.E.I.C., Port Cartier, Que.

OAKVILLE
Chairman, G. A. Alexander, M.E.I.C., P.O. Box 550, Oakville, Ont.
Secretary-Treasurer, R. G. Montrose, M.E.I.C., 237 Pinehurst Drive, Oakville, Ont.

OTTAWA
Chairman, A. B. Connelly, M.E.I.C., Kent-Albert Building, 150 Kent Street, Ottawa, Ont.
Secretary, James N. Pritchard, M.E.I.C., 2234 McQuaig Street, Ottawa 1, Ont.

PETERBOROUGH
Chairman, W. C. Durant, M.E.I.C., 1244 Clonsilla Avenue, Peterborough, Ont.
Secretary-Treasurer, R. H. Rehder, M.E.I.C., 14 Middleton Drive, Peterborough, Ont.

PORT CREDIT
Chairman, T. H. Rosborough, M.E.I.C., 1408 Broadmoor Avenue, Port Credit, Ont.
Secretary-Treasurer, Harry D. Smith, 790 Melton Drive, Port Credit, Ont.

PORT HOPE
Chairman, J. S. Coopman, M.E.I.C., 57 Victoria Street, Port Hope, Ont.
Secretary-Treasurer, Ross H. Abbott, M.E.I.C., Peter Street, Port Hope, Ont.

PRINCE EDWARD ISLAND
Chairman, W. S. Veale, M.E.I.C., P.O. Box 1268, Charlottetown, P.E.I.
Secretary-Treasurer, E. S. Chandler, M.E.I.C. 242 North River Road, R.R. 2, Charlottetown, P.E.I.

QUEBEC
Chairman, J. B. Delage, M.E.I.C., 2774 Montarville, Ste. Foye, Que.
Secretary-Treasurer, Jacques Plamondon, A.M.E.I.C., 14 Avenue Bon-Air, Quebec 10, Que.

RICHMOND HILL
Chairman, Kenneth Brown, M.E.I.C., 24 Idleswift Drive, Box 777, Thornhill, Ont.
Secretary-Treasurer, Jack P. Miller, M.E.I.C., 7 Sussex Avenue, Richmond Hill, Ont.

OFFICERS OF THE BRANCHES

SAGUENAY
Chairman, D. H. Dobbs, M.E.I.C., 212 Gay Lussac, Arvida, Que.
Secretary-Treasurer, Guy Robin, M.E.I.C., 258 St. Leon Street, Jonquiere, Que.

SAINT JOHN
Chairman, D. I. Higgins, M.E.I.C., 30 Elizabeth Court, Saint John, N.B.
Secretary-Treasurer, Eldon D. Thompson, A.M.E.I.C., P.O. Box 4, Champlain Heights, Saint John, N.B.

SAINT MAURICE VALLEY
Chairman, W. M. Ingram, M.E.I.C., P.O. Box 269, Shawinigan, Que.
Secretary-Treasurer, MacGregor Fraser, M.E.I.C., Laurentide Inn, Grand'Mere, Que.

SARNIA
Chairman, R. W. Hogson, M.E.I.C., 885 Kemsley Street, Sarnia, Ont.
Secretary-Treasurer, F. J. Routledge, M.E.I.C., 1031 Arbour Court, Sarnia, Ont.

SASKATCHEWAN
Chairman, M. F. Pardoe, M.E.I.C., 645-19th Street W., Prince Albert, Sask.
Secretary-Treasurer, Reginald Bing-Wo, M.E.I.C., 10 Davis Place, Regina, Sask.

SASKATCHEWAN BRANCH SECTIONS

REGINA
Chairman, R. H. Cook, M.E.I.C., 2826 Assiniboine Avenue, Regina, Sask.
Secretary-Treasurer, R. J. Briggs, M.E.I.C., 2905 Wascana Street, Regina, Sask.

MOOSE JAW
Chairman, Flt. Ltd. Vern McKinnon, 942-1st St. N.E., Moose Jaw, Saskatchewan.
Secretary-Treasurer, Gordon Skorobohach, 1194 Currie Cresc., Moose Jaw, Sask.

PRINCE ALBERT
Chairman, Gary E. Baldwin, M.E.I.C., Department of Highways, North Battleford, Sask.
Secretary-Treasurer, John L. M. Scott, M.E.I.C., Box 1298, Department of Highways, Prince Albert, Sask.

ESTEVAN
Chairman, G. R. Ursenbach, M.E.I.C., P.O. Box 136, Estevan, Sask.
Secretary-Treasurer, G. H. Funke, A.M.E.I.C., P.O. Box Box 446, Estevan, Sask.

SASKATOON
Chairman, F. W. Catterall, M.E.I.C., 518-6th Street, Saskatoon, Sask.
Secretary, F. W. Fossey, M.E.I.C., c/o Douglas, Michalenko & Dupuis, Saskatoon, Sask.

YORKTON
Chairman, R. G. Brown, M.E.I.C., Box 579, Yorkton, Sask.
Secretary-Treasurer, C. L. Slegee, M.E.I.C., 83 Elizabeth Avenue, Yorkton, Sask.

SAULT STE. MARIE
Chairman, K. I. Fletcher, M.E.I.C., 41 McCrea Street, Sault Ste. Marie, Ont.
Secretary-Treasurer, M. R. Wright, A.M.E.I.C., 14 Queen Street E., Suite 4, Sault Ste. Marie, Ont.

SUDBURY
Chairman, J. N. Raftis, M.E.I.C., Canadian General Electric Co., P.O. Box 97, Sudbury, Ont.
Secretary-Treasurer, H. S. Judges, A.M.E.I.C., Box 769, Copper Cliff, Ont.

TORONTO
Chairman, D. R. Abbey, M.E.I.C., 8 Briarfield Road, Don Mills, Ont.
Secretary-Treasurer, E. S. Bell, M.E.I.C., 6 Lakeland Crescent, Scarborough, Ont.

VANCOUVER
Chairman, D. Bakewell, M.E.I.C., 1398-20th Street, Hollyburn, B.C.
Secretary, T. Covello, M.E.I.C., 1161 Melville Street, Vancouver 5, B.C.

VANCOUVER ISLAND
Chairman, A. R. D. Robertson, M.E.I.C., 3161 Service Street, Victoria, B.C.
Secretary-Treasurer, W. Strok, 640 Queens Avenue, Victoria, B.C.

WHITBY
Chairman, To be appointed.
Secretary-Treasurer, Roy G. Beckman, M.E.I.C., 205 Bowman Avenue, P.O. Box 481, Whitby, Ont.

WINNIPEG
Chairman, R. E. Chant, M.E.I.C., Dept. of Mechanical Engineering, University of Manitoba, Fort Garry, Man.
Secretary-Treasurer, W. N. Isberg, M.E.I.C., 20 Willowridge Drive, Winnipeg 12, Man.

WINNIPEG BRANCH SECTION

BRANDON
Acting Secretary, J. E. Harrison, Metals Industries Limited, Box 522, Brandon, Manitoba.

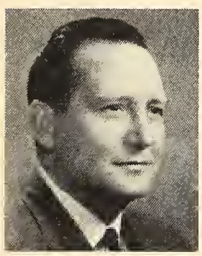
YUKON
Chairman, J. E. Kellett, M.E.I.C., P.O. Box 2560, Whitehorse, Yukon.
Secretary, D. A. Whiffin, A.M.E.I.C., Northwest Highway Maintenance Est., Camp Takhini, Whitehorse, Yukon.

ONTARIO DIVISION
Chairman, Dean H. G. Conn, M.E.I.C., Queen's University, Kingston, Ont.
Secretary, A. C. Davidson, 106 Bideford Street, Downsview, Ont.

NEWLY ELECTED OFFICERS OF THE INSTITUTE

During the Annual Meeting eight new Vice-Presidents and numerous Councillors assumed office to serve with others whose term of office continues. Following are short biographies of some of the new councillors. Additional biographies of the Vice Presidents and Councillors will appear in later issues of the Engineering Journal.

Herbert A. Marshall, M.E.I.C., Councillor for Halifax, is Senior Sales Co-ordinator for Imperial Oil Limited. Mr. Marshall received his B.Sc. from Dalhousie in 1941, and a B.Eng. from the Nova Scotia Technical College in 1943. He has been a member of the Institute since 1946. In 1953, he was Chairman of the Cape Breton Branch; in 1954 Councillor of the Branch, and in 1960, Chairman of the Halifax Branch. He is Vice President of the A.P.E.N.S., an Executive member of the Mining Society of Nova Scotia, and President of its Nova Scotia Branch.



H. A. Marshall, M.E.I.C.

M. Benoit, M.E.I.C.

Marc Benoit, M.E.I.C., re-elected Montreal Councillor, is a partner in the firm of Asselin, Benoit, Boucher, Ducharme & Lapointe, Consulting Engineers. Mr. Benoit graduated from Ecole Polytechnique in 1944 with a B.A.Sc. degree. He became a member of the Institute in 1944. Mr. Benoit was Chairman of the Montreal Branch's Publicity Committee during 1956-57. He is a member of the Hydro Technical Division of the Committee on Technical Operations. Mr. Benoit is a member of various committees in the C.P.E.Q., a member of the A.C.I. and the Montreal Chamber of Commerce.

William L. Hutchison, M.E.I.C., Vice President of Moffats Limited, Weston, Ont., has become Councillor for Toronto. Mr. Hutchison, who received his B.Eng. from McGill in 1934, became a member of the Institute in 1943. He has since been Chairman of the Hamilton Branch, 1952, and Chairman of the Toronto Branch, 1961. He was Chairman of the Management Division, Committee on Technical Operations. Mr. Hutchison is a member of the Dollar Sterling Trade Council, the Canadian Manufacturing Association, and is Vice President of the Humber Valley Homeowners Association.

G. B. Williams, M.E.I.C.

P. A. Dupuis, M.E.I.C.

G. B. Williams, M.E.I.C., Councillor for Ottawa, is Assistant Deputy Minister in the Department of Public Works. Mr. Williams, who received his B.Sc. in 1935, became a member of the Institute in 1945. Since then, he has been Chairman of the Winnipeg Branch, 1953-54 and the Ottawa Branch, 1961-62. Mr. Williams is Chairman of the Technical Advisory Committee in the Canadian Good Roads Association, and Past President of the Manitoba Association of Professional Engineers.

Philipe A. Dupuis, M.E.I.C., Vice President of Metro Industries Co. Ltd., has been elected Councillor for Quebec City. Mr. Dupuis, a Civil Engineer, graduated in 1921. During 1947, he was President of the Quebec Branch, and in 1952, Président Général of the Association des Diplômés de Polytechnique. He was Honorary Secretary of the C.P.E.Q. in 1952. He was decorated with l'Ordre du Mérite by the students of Ecole Polytechnique in 1952.

Wesley M. Steeves, M.E.I.C., elected Councillor for Moncton, is Moncton's City Engineer. Mr. Steeves, who graduated from the University of New Brunswick with a B.Sc. in Civil Engineering in 1948, was a student member of the Institute two years earlier, and became a full member in 1955. Mr. Steeves was Vice Chairman of the Moncton Branch in 1958-59, and Chairman in 1959-60. He is a member of the Nominating Committee. Active in community affairs, Mr. Steeves is on the executive of several local organizations.

W. A. Wheten, M.E.I.C.

W. M. Steeves, M.E.I.C.

Waldo A. Wheten, M.E.I.C., City Engineer and Manager of Waterworks, is Councillor for Hamilton. Mr. Wheten received a B.Sc. from the University of Saskatchewan in 1938. He was Chairman of the Hamilton Branch in 1955. Mr. Wheten's other activities include membership in the Hamilton Rotary Club, and the Hamilton and District Officers Institute.

Robert D. Hall, M.E.I.C., Councillor for Lethbridge, is Utility Director for that city. Mr. Hall graduated with a B.Sc. in Electrical Engineering from the University of Alberta in 1948. He was a student member of the Institute in 1947, a junior member in 1949, and became a full member in 1959. He was secretary-treasurer of the Lethbridge Branch from 1952-1958, and was Chairman in 1959. Active in local affairs, Mr. Hall is a member of the Henderson Lake Golf Club, and the Lethbridge Curling Club. He is a member of the Board of Stewards at Southminister United Church. He was a member of Council in the A.P.E.A. during 1958-1960.

John F. Runge, M.E.I.C., elected Councillor for Kitchener, is Manager, Building Sales at Armco Drainage & Metal Products of Canada Ltd. Mr. Runge has served successively as Secretary, and Chairman of the Kitchener Branch. Other activities include membership in the Guelph Lions Club.

J. H. Swerdfeger, M.E.I.C.

J. F. Runge, M.E.I.C.

John H. Swerdfeger, M.E.I.C., Councillor for Vancouver, is a partner in the firm of McCarter, Nairne & Partners, Architects and Consulting Engineers. Mr. Swerdfeger received a B.A.Sc. from the University of British Columbia in 1944. He had been a student member of the Institute since 1941, and became a full member in 1949. Since becoming a member, Mr. Swerdfeger has been Chairman of the Technical Sections at the Branch, Vice Chairman of the Branch, 1959-60; and Chairman of the Branch 1960-61. Mr. Swerdfeger is past Chairman of the Civil Board of Examiners, in the A.P.E.B.C.

Roy E. Ludwig, M.E.I.C., Councillor for the Saskatchewan Branch, is an Associate Professor at the University of Saskatchewan. Mr. Ludwig graduated from the University of Manitoba with a B.Sc. in 1946, and from the University of Illinois with a M.Sc. in 1950. He became a junior member of the Institute in 1948, and a full Member in 1950. From 1959 to 1961, he was a member of the executive committee of the Saskatchewan Branch.

William M. Hogg, M.E.I.C., Councillor for Sault Ste. Marie, is President of the Great Lakes Power Company, Limited. Mr. Hogg graduated from the University of Toronto with a B.A.Sc. in 1939. He became a member of the Institute in 1943. Mr. Hogg was a member of the Branch Executive Committee in 1957, and the Branch Membership Committee from 1957 to 1959. He is Vice President of the local Chamber of Commerce; Chairman of the Board at the Algoma College Association; a Trustee in the Welfare Federation, and a Past Chairman of the United Appeal.

W. M. Hogg, M.E.I.C.

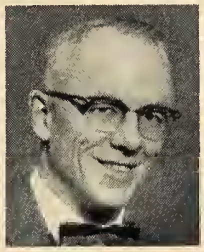
R. J. Kane, M.E.I.C.

Redmond J. Kane, M.E.I.C., Councillor for Montreal, is a partner in the firm of Melamed, Kaiser & Kane, Consulting Engineers. Mr. Kane, who received a B. Eng. degree from McGill University in 1941, has held the offices of Program Committee Chairman, Admissions Chairman, Membership Chairman with the Montreal Branch. He is a member of the Institute's Membership Committee. Mr. Kane's other activities include the Professional Training Division of the C.P.E.Q., and participation in various charitable organizations.

Frederick L. Perry, M.E.I.C., Councillor for Calgary, is Technical Superintendent of the Imperial Oil Limited. He received a B.Sc. in Chemical Engineering from Queen's University in 1942. He became a member of the Institute in 1943. Mr. Perry has held the following Branch offices: Technical Program Chairman, 1956-57; Professional Development Committee, 1957-58; Branch Chairman, 1958-59. He was a member of the Meeting Arrangement Committee at the 71st Annual Meeting at Banff in 1957 and a Striking Committee Member in 1959. Mr. Perry is Secretary of the local Home and School Association and his interests include the Boy Scout Association and the Canadian Youth Hostels Association.

Adam Sandilands, M.E.I.C., Councillor for Edmonton, is Manager, Alberta Region, for Phillips Electrical Co. Ltd. Mr. Sandilands graduated from the University of Manitoba in 1934 and received a B.Sc. degree in Electrical Engineering. He was a student member of the Institute in 1931, a junior member in 1938, and became a full member in 1940. Mr. Sandilands is immediate Past Chairman of the Edmonton Branch, is Vice Chairman of the Branch, and is Chairman of the Program Committee. His other activities include membership in the Rotary Club of Edmonton, the Edmonton Chamber of Commerce and the Edmonton Electric Club.

Leonard A. Bateman, M.E.I.C., elected Councillor for Winnipeg, is Director of Production at Manitoba Hydro. Mr. Bateman became a member of the Institute in 1948. He graduated in 1942 with a B.Sc. degree, and obtained a M.Sc. in 1948. He has served as Chairman of the Electrical Section, Winnipeg Branch; as Chairmen of the Branch; and in 1958, as President of the Manitoba Association of Professional Engineers.



L. A. Bateman, M.E.I.C.

H. A. Mullins, M.E.I.C.

Harrison A. Mullins, M.E.I.C., Supervising Construction Engineer of DuPont Canada Ltd., has become Councillor for the Montreal Branch. Mr. Mullins who received his B.Sc. in Electrical Engineering from the University of Manitoba in 1937, was on the executive committee of the Montreal Branch during the late 1940's and early 1950's. He was Vice Chairman of the Montreal Branch in 1960, and Chairman in 1961. Mr. Mullins was Chairman of the Institute's Publications Committee from 1955 to 1957. He was a Councillor, Montreal Branch from 1955 to 1957.

16th ANNUAL
SOIL MECHANICS CONFERENCE
EDMONTON
SEPTEMBER 12 & 13, 1962

WEDNESDAY, SEPTEMBER 12
Morning Technical Conference Theme: "*Volume Change Characteristics of Highly Plastic Soils*"
Afternoon Technical Conference Theme: "*Physico-Chemical Aspects of Soils*"

THURSDAY, SEPTEMBER 13
Combined Meeting of Soil Mechanics and Zone "A" Technical Meeting
Technical Conference Theme: "*Recent Developments of Energy Resources in Western Canada*"

FRIDAY, SEPTEMBER 14
Zone "A" Technical Meeting
Technical Conference Theme: "*Recent Developments of Energy Resources in Western Canada*"

Canadian Chemical Engineering Conference
Sarnia, Ontario — October 22-24, 1962

SPONSORED BY: The Chemical Engineering Division of the Chemical Institute of Canada and the Chemical Engineering Division of the Committee on Technical Operations of the Engineering Institute of Canada.

TECHNICAL SESSIONS: Symposia on Heat Transfer, Mass Transfer, Training Methods for Chemical Plant operators, Pollution, chemical plant maintenance and chemical reactions in addition to a number of general sessions.

PLANT TOURS: Canada's "Chemical Valley", a vast complex of petroleum refineries and chemical manufacturing plants.
GUEST SPEAKERS: Dr. F. A. Forward
R. E. McBurney
Jamie Newell

WHAT IS THE EIC? AN OVER-ALL VIEW

If unexpectedly asked the question: What is the EIC?, it is probable that many members of EIC would be somewhat taken back and would have to stop and reflect a few minutes. This is perfectly logical because the EIC is the over-all image of all its constituents. What are its constituents? Well, in the first place these are our members. Collectively they are the Institute. Hence, the collective view the Canadian public has of our members creates in the minds of the public the over-all image of EIC. If our members are passive and take but little part in community life or in the voluntary, professional, technical and learned society of their profession in order to better serve the public, our public will not have a very impressive or clear view of EIC. On the other hand, if the members are active in the Institute and in the community, contribute of their time and effort, there is little doubt that the community will recognize the Institute as a vital force in Canadian life. Let me emphasize it once again: "The image" of the Institute is compounded of the active participation of each one of its members.

A recent issue of the Royal Bank of Canada Monthly Letter on the subject of Corporate Images and Emblems said "This image is not a sort of brooding Buddha, but something very full of life, pulsating with the vigor of achievement and dynamic with growth". This observation is just as significant for the EIC as for any industrial corporation, bank or other collective form of economic activity.

So that members can effectively participate in that interchange and dissemination of professional knowledge and experience which is so important in the development of engineers as professional men, the Institute is organized with branches and student sections. These vital elements of EIC organization contribute to the image of the Institute in a very substantial manner because the Institute is but a reflection of some 62 Branches and 12 Student Sections. If Branches and Student Sections are well organized to provide a continuing sense of professional coherence in the dissemination of information and experience, to an informed and enthusiastic Branch membership, it is virtually certain that the image of that Branch will be far brighter than if it proceeds on a "laissez faire" basis. The same holds for Student Sections. This means that both Branches and Student Sections have a vital role to play in ensuring that the public recognizes not only the role but the contribution of the profession through its voluntary, technical, professional and learned society organization, The Engineering Institute of Canada.

The actions of many other units and personnel of EIC contribute materially to the image of the Institute. Councillors and other officers do contribute markedly when they are vital and enthusiastic members, enthusiastic and constructive in their views on the contribution which EIC is making to Canadian life. This is more important than ever with the growing complexity of modern economic life.

I hope I can count on each one of you to play your role not only enthusiastically but with a vision of a stronger and more effective EIC.

F. L. Lawton, President.

CE QU'EST L'ICI? UNE VUE D'ENSEMBLE

Si on demandait à l'improviste ce qu'est l'ICI, il est probable que plusieurs membres de l'ICI seraient pour le moins déconcertés, auraient à s'arrêter un moment et réfléchir sur la question. Ceci est compréhensif, en ce sens que, l'ICI est une image superposée de divers constituents. Quels sont ses constituents? Voici, en premier lieu, ce sont nos membres. Collectivement, ils sont l'Institut. Ainsi, la vue d'ensemble qu'a le public canadien de nos membres, crée dans l'esprit de ce public, l'image même de l'ICI. Si nos membres sont passifs, s'ils ne prennent peu ou aucune part à la vie communautaire, ou bien dans les activités de la Société qui est volontaire, professionnelle, technique et savante qu'est l'ICI, afin de pouvoir mieux servir le public, alors, la population aurait une impression bien peu précise de l'ICI. D'autre parts, si les membres sont actifs au sein de l'Institut et dans la communauté, s'ils contribuent de leur temps et de leurs efforts, il y aura peu de doute que le public reconnaitra l'Institut comme une force vitale à l'économie de la vie canadienne. Permettez-moi de le souligner encore une fois "l'image de votre Institut est en fonction de l'active participation de tous ses membres".

Dans un journal mensuel récent—"Lettre mensuelle de la Banque Royale du Canada", il est dit sur le sujet des Images Corporatives et des Symboles: "Cette image n'est pas un genre de Buddha rêveur, mais bien quelque chose pleine de vie, vibrante à la cadence de la vigueur de ses réalisations et dynamique dans sa croissanee. Cette observation est autant significative pour l'ICI, que pour n'importe quelle corporation industrielle, banque ou autres formes d'activités collectives économiques.

Afin que les membres puissent participer effectivement à l'échange et à la diffusion des connaissances et expériences de la profession, ce qui est une partie importante au développement de l'Ingénieur comme homme professionnel, l'Institut est organisé de Branches et de Sections d'Etudiants. Ces éléments vitaux de l'organisation de l'ICI contribuent fortement à l'image que l'on se fait de l'Institut, parce que l'Institut est seulement le reflect de quelques 60 Branches et de 12 Sections d'Etudiants. Si ces Branches sont bien aménagées, de façon à procurer une cohérence d'informations et d'expériences professionnelles des membres ethousiastes et bien informés de la Branche, alors, il est virtuellement certain que l'image de la Branche sera beaucoup plus expressive que si elle procède sur une base de nonchalance. La même condition existe pour les Sections des Etudiants. Ceci veut prouver que les Branches et les Sections ont un rôle prépondérant à jouer dans la société, afin de s'assurer que le grand public reconnaitra non seulement le rôle, mais aussi la contribution de la profession par le moyen de sa savante société qui est volontaire, technique, professionnelle, L'Institut Canadien des Ingénieurs.

Les actions du personnel et de plusieurs autres unités de l'ICI contribuent aussi, matériellement, à la composition de l'image de l'Institut. Les conseillers et autres officiers apportent leurs marques à cette image quand ils sont des membres actifs et enthousiastes; enthousiastes et constructifs aussi dans leurs actions, concernant la contribution qu'apporte l'ICI à la vie canadienne. Ceci est plus important que jamais devant la complexité progressive actuelle, et moderne, de notre vie économique.

J'espère que je puisse compter sur chacun de vous pour jouer son rôle allègrement, non seulement avec dynaminsme mais aussi avec vigueur afin de faire de l'ICI une organisation plus forte et encore plus efficace.

F. L. Lawton, Président.

16th Annual

CANADIAN

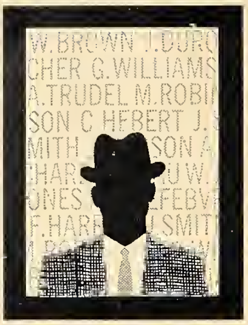
SOIL MECHANICS

CONFERENCE

EDMONTON, ALTA.

September 12-13, 1962

Personals



Frank E. Miller, M.E.I.C. (Toronto '42) has been appointed vice-president and general manager of the Pressure Pipe Division at Canada Iron Foundries, Limited.

A. F. Seraphim, M.E.I.C. (U.B.C. '45) has been appointed Vice-President and Construction Manager of the Mannix Company Ltd. Mr. Seraphim has been associated with the company since 1960. Prior to that, he had been associated with Northern Construction Company and J. W. Stewart Ltd., of Vancouver, serving as job engineer, project manager, division manager and assistant to the president. He was elected to the company's board of directors in 1959. Mr. Seraphim, has been involved in many of the largest construction projects in Canada, including the D.E.W. Line, St. Lawrence Seaway, and Ripple Rock Project.

Stan W. Pappius, M.E.I.C. (Royal Naval Engrg. Coll. England '45) has been appointed Manager of the Platework Division at the Montreal Branch of Dominion Bridge Company. Mr. Pappius has been sales manager of the company's Mechanical Division. Before joining the company two years ago, he gained wide experience in engineering and sales work in Canada over a period of 11 years, particularly in the fields of power utilities.

E. W. Dill, M.E.I.C. (Toronto '28) has been appointed manager, public relations at Polymer Corporation. Mr. Dill came to Sarnia in 1942 as design engineer with a large consulting firm. He was involved in the construction of Polymer's steam and power plant. When the plant went into operation, he joined the company as its first superintendent and was later transferred to the employee relations division.

G. N. Farantatos, M.E.I.C. (McGill '52, Toronto '53) has been appointed Manager of the Civil Engineering Branch of Giffels & Vallet of Canada, Ltd., Consulting Engineers with offices in Toronto, Windsor, Ottawa and Sarnia. Mr. Farantatos has been responsible for work in this field since 1956.

Fred H. Knelman, M.E.I.C. (Tor. '43, McGill '50) has been appointed technical director of Stuart Brothers Company Limited. Dr. Knelman joined the company in 1953 in the research and development department. In his new position, he will be responsible for production quality control, research and development. Dr. Knelman was President of the Montreal chapter of the Canadian Institute of Food Technologists during 1957-58, and in 1961, took part in the Symposium on Education at the Congress of Chemistry in Montreal. A member of the Canadian Institute of Food Technology and the American Association for the Advancement of Science, Dr. Knelman has acted as a consultant to the Canadian Broadcasting Corporation and the National Film Board on scientific programmes and documentary films.

L. S. Love, M.E.I.C. (McGill '51) has been appointed sales manager of the water and sewage treatment department of Babcock-Wilcox and Goldie-McCulloch Limited, of Galt, Ont. Mr. Love has had 10 years experience in water and sewage treatment work and process equipment manufacturing.

H. G. Welsford, LIFE M.E.I.C. has been elected a Director of Canadian General Electric Company Limited. Mr. Welsford is President of Dominion Bridge Company Limited and a Director of a number of important Canadian companies.

Dr. Geoffrey G. Meyerhof, M.E.I.C. (London Univ. '38) has been appointed Director of Graduate Studies in the new School of Graduate Studies of the Nova Scotia Technical College, Halifax, N.S. Dr. Meyerhof will remain Head of the Department of Civil Engineering of the College, which he joined in 1955 as Professor of Civil Engineering.

Lindley Sheetor, M.E.I.C. (McGill '37), and **Jean Forte,** M.E.I.C. (Ecole Poly. '51) have formed the firm of Sheetor and Forte, Consulting Engineers. They will specialize in foundation and structural design and supervision in the commercial, institutional and industrial fields, where both have had wide experience. For the past sixteen years, Mr. Sheetor was structural consultant to and associate of the firm of Barott, Marshall & Merrett, Architects, participating in the design of, and completely in charge of the structural work on such buildings as the Royal Victoria Hospital extensions, Bell Telephone Toll Building, new Head Office for the Bank of Montreal and the Montreal Star Building.

John W. Korcz, M.E.I.C. (McGill '47) has been appointed Plant Manager of Reynolds Aluminum Company Ltd., at Cap de la Madeleine, Que. Mr. Korcz joined the company in 1947 and has held various engineering positions including that of Chief Engineer, the position he held prior to his recent appointment.

Douglas R. J. Kay, M.E.I.C. (A.M.I. Mech. Eng. '56) has been appointed Montreal District Sales Manager for Provincial Engineering Ltd., Niagara Falls. Mr. Kay will be responsible for crane and hoist sales in the Quebec and Maritime areas.

George Flavell, M.E.I.C. (Man. '48), has been appointed Calgary branch apparatus sales manager for the Canadian Westinghouse Company Limited. Mr. Flavell joined Westinghouse in 1948 and has been a sales engineer at Winnipeg for the past ten years. Mr. Flavell was Chairman of the Engineering Institute of Canada's Electrical Section in 1939 and is a member of the Institute's Council.

D. B. Smith, M.E.I.C. (Univ. Alta. '54) has assumed the position of Alberta Branch Manager of Armco Drainage and Metal Products of Canada Ltd. Mr. Smith was previously Alberta Sales Manager.

NEED WE SAY MORE?

IN 1888 THE FOLLOWING PRICES APPLIED IN MONTREAL:

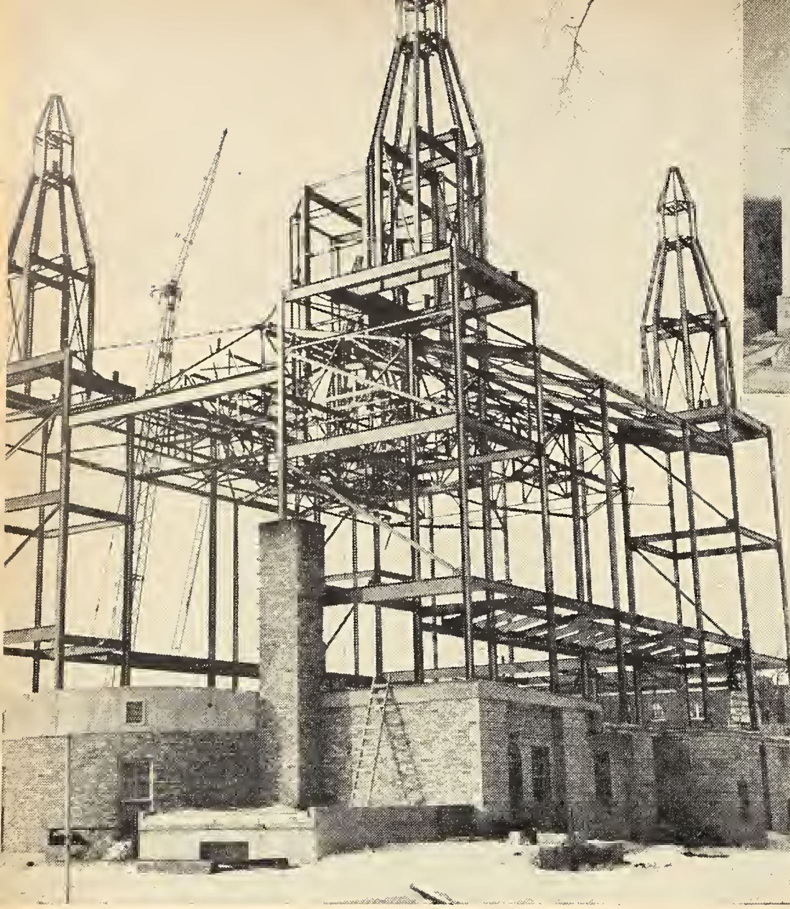
Eggs	17 cents a dozen
Butter	15 cents a pound
Cheese	9 cents a pound
Dining Room Set	from $10
Eleven-piece bedroom set	$30

A three-storey, 16-room home in a choice residential location. Includes kitchen, dining room, billiard room. Heated by hot air and water — $6,250.

IN 1888 THE FOLLOWING WAS THE FEE STRUCTURE FOR THE PREDECESSOR OF THE ENGINEERING INSTITUTE OF CANADA:

Resident Member	$10
Non-resident Member	8
Resident Associate Member	8
Non-resident Associate Member	6
Associate	10
Student	2

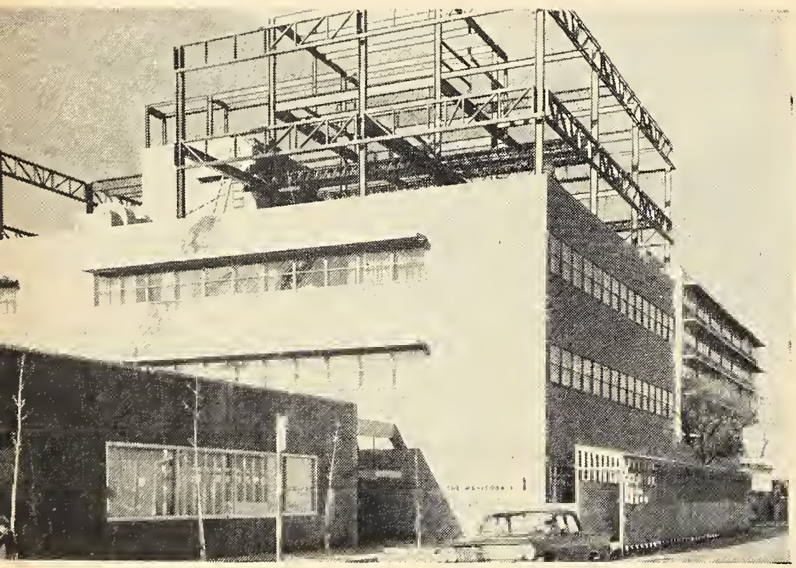
G. N. Martin, M.E.I.C.,
Chairman, Finance Committee



Steel is versatile

Structural steel can be used to build complex desi shapes. This steel frame is for the Greek Orthod Holy Trinity Cathedral in Winnipeg and inset the finished building.

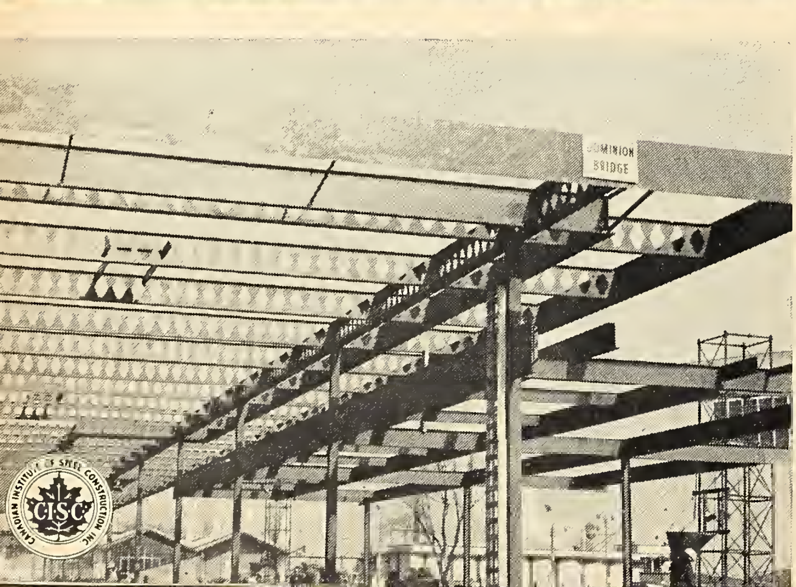
Architects: Green, Blankstein, Russell & Associates.



Additions are easy with steel

When this building was first constructed two ext floors at a later date were a possibility. Last ye they became a reality. The tops of the main suppo columns of the original steel frame had been l exposed and the new steel was added quick and economically.

Architects: Smith, Carter, Searle & Associates.



Castellated steel beams reduce weight

The use of castellated beams in the C.N.E. Hon Furnishing Building in Toronto resulted in ro purlins that were about 75% of the weight of equally strong rolled beam and about 60% of t weight of an equally rigid rolled beam. Beams a castellated by cutting the web zigzag fashio offsetting the halves one notch and rewelding pe to peak. Castellated beams can free the design from the restrictions of excessive deflections wh using the new high strength steels.

Architects: Marani, Morris & Allan.
Consulting Structural Engineer: W. Sefton & Associates, Limited.

1st NORTH EASTERN QUEBEC
REGIONAL CONFERENCE
The Engineering Institute of Canada
BAIE COMEAU — AUGUST 24, 1962

Sponsoring Branch: Baie Comeau

Participating Branches: Seven Islands, Port Cartier, Rimouski

Sponsored by the Baie Comeau Branch to mark the 75th Anniversary of the E.I.C. and the 25th Anniversary of the town of Baie Comeau, the Technical Conference also aims to publicize some of the latest technical developments and studies in the Lower St. Lawrence and to provide a get-together to all E.I.C. members in the area. The Conference will be bilingual and papers presented in both languages.

THURSDAY, AUGUST 23, 1962

1. **Advance Registration—Manoir Comeau**
2. **Informal Reception**
3. **8.30 p.m.—Meeting of Committee on Branch Operations**

FRIDAY, AUGUST 24, 1962

1. 8.00-9.00 a.m.—Registration
2. 9.00-Noon—Technical Papers
   "Unique Wharf Breakwater System" (English)
   A. H. C. Carson, M.E.I.C.
   "7-Mile Pulpwood Flume Construction" (English)
   C. B. Prosser, A.M.E.I.C.
   "Electrical Measurements in the Aluminum Industry" (French)
   Y. Plunier
3. Noon-2.15 p.m.—Informal Reception, Lunch and Presidential Address
4. 2.15-6.15 p.m.—Technical Papers
   "Photogrammetry, Principle and Application" (French)
   R. Rinfret
   "Study of the Ice Movement on the St. Lawrence" (French)
   D. Caveen, M.E.I.C.
   (*Continued next column*)
   "Paper Machine Calender Stack" (English)
   B. I. Howe, A.M.E.I.C.
   "Muskeg and the Iron Ore Railway" (English)
5. 7.30 p.m.—Cocktails, Cold Buffet, Dance

SATURDAY, AUGUST 25, 1962

1. 6.45 a.m.—Breakfast
2. 7.30 a.m.—**Field Meeting**—Depart for Quebec Hydro Project 5, 135 miles north of Baie Comeau along the Manicouagan River
3. 10.30 a.m.—Arrival at Project Technical Briefing—A. Rousseau, M.E.I.C.
4. Noon—Informal Reception and Lunch
5. 2-5 p.m.—Visit of Project Manicouagan 5
6. 7.30 p.m.—Informal Supper at the Manoir Comeau

SUNDAY, AUGUST 26, 1962

1. 10.30 a.m.—**Golf Tournament**—Open to all E.I.C. members and P.Engs. Numerous Trophies.
2. 2.30 p.m.—Tour of local industries

In view of the restricted accommodation in Baie Comeau, all reservations will be handled and processed by the Baie Comeau Branch.

When writing for reservations, please specify type, dates required, and preference if any (Auberge du Roc, Manoir Comeau, Motel le Plateau, le Pavillon).

No reservations accepted after Monday, August 20, 1962.

CONFERENCE COMMITTEE
BOX 575
BAIE COMEAU, QUEBEC.

There will be a special program for the ladies.

It should be noted that the actual Regional Conference will terminate on Friday night, August 24, and that the Field Meeting to the Manicougagan has been primarily scheduled to accommodate visitors interested in this tremendous Hydro-Electric Project. A car pool will be available.

News of the Branches

BELLEVILLE

A. F. G. Tooth, M.E.I.C.

Members of the Branch visited R.C.A.F. Station, Trenton on May 14, to hear an address by Wing Commander C. H. A. Thompson, Senior Technical Staff Officer of Air Transport Command Headquarters on the operations of R.C.A.F. Air Transport Command.

W/C C. H. A. Thompson welcomed members and guests of the Engineering Institute of Canada to Air Transport Command Briefing Room where he gave a very informative talk on the general requirements and support necessary to operate an organization such as Air Transport Command. It was interesting to note that A.T.C. operated flights for various reasons for the R.C.A.F. as well as NATO and the United Nations in practically all of the free world on a regularly scheduled basis. W/C Thompson demonstrated how this organization operates efficiently by pointing out the support of other groups within A.T.C. The Officers in Charge of the Construction Engineering Section, Aeronautical Engineering, Vehicle and Marine Engineering Sections gave detailed descriptions of the various sections. W/C Thompson and the other Officers were thanked by A. G. Tooth.

New Branch Officers for 1962 elected at the April meeting are: Chairman, W. J. N. Throop; Vice Chairman, A. F. G. Tooth; Secretary-Treasurer, E. H. Gilroy.

CAPE BRETON

Lloyd Boutilier

Major R. A. Bradley of the 3rd Militia Group, Sydney, N.S., was the guest speaker at the Branch's April 5 meeting. Major Bradley spoke on the Municipal Fallout Shelter Survey. He discussed the effects of a five megaton nuclear explosion, describing the blast damage, thermal radiation, initial radiation, secondary effects and fallout. Maj. Bradley then presented the theory of shielding. He described barrier shielding, geometry shielding, and gave the purposes of fallout shelters.

The basic requirements for a community fallout shelter were outlined. Habitability factors, core concept, space per person, heat, light and cooking facilities, water and sanitation and food requirements were discussed. Maj. Bradley said that the public must be made aware of the necessity for early preparation to ensure some form of fallout shelter. Information is available from the Civil Defence Offices. Maj. Bradley recently attended a course on Civil Defence at the Civil Defence College at Arnprior, Ont.

CENTRAL BRITISH COLUMBIA

A. F. Joplin, M.E.I.C.

A joint dinner meeting of the Branch and the local APEO was held May 18 at the Kelowna Golf and Country Club. J. W. Nelson introduced the guest speaker Dr. B. G. Ballard, and President of the Engineering Institute of Canada, who said that future engineering achievements will have to be greater to meet the ever changing technology. Dr. Ballard has recently been reviewing the work of engineers from coast to coast in Canada. In the next ten years, engineers must play an important role in Canada's advancement.

Dr. Ballard said that energy consumption in Canada is increasing six per cent per year. This increase will result in the need to double that capacity in the next 12 years. Dr. Ballard finds British Columbia fortunate as far as hydro development is concerned. Throughout Canada now, work is being done in the direct conversion of fuel to electrical energy in fuel cells. Work is also underway on the direct conversion of atomic energy to electrical energy.

Dr. Ballard predicted that television communications between the East and West by satellite will be a major contribution by science to the peace of the world. This direct means of communication will be established within the next ten years.

M. Elston, of the Department of Highways, thanked Dr. Ballard. Branch Chairman, B. Harvey, introduced all the guests including R. F. Parkinson, Mayor of Kelowna. He reminded the Branch members of the field visit to the engineering works in the Rogers Pass area which was planned for June 1.

EDMONTON

R. J. Allman, M.E.I.C.

The Branch held a meeting April 25 at the MacDonald Hotel. The speaker was Dr. G. M. Shrum, President of B.C. Electric, who spoke on Power Developments in British Columbia.

Dr. Shrum gave a very informative and concise picture of power development in the province and explained in detail both the present and future power plans for British Columbia. He said that he expects the Federal Government to come to terms very shortly with British Columbia on the development of power on both the Columbia and the Peace Rivers. He said that if Ottawa would give British Columbia permission to sell its share of the downstream benefits of power from the Columbia River, the province would agree to the treaty already signed between Canada and the United States. In return for the right to sell downstream power for 20 years at five mills per kilowatt hour, British Columbia would accept the treaty, ask no financial assistance from Ottawa for power developments on either the Columbia or the Peace Rivers, and would use all funds received from the sale of downstream power to develop dams on the Columbia River.

Dr. Shrum said that British Columbia does not want to bring downstream power back into the Province. Instead, it wants dollars returned to develop upstream power. He said that B.C. has enough power resources to support a population of between 25 and 30 million persons, and they are not concerned about exporting power, as in other parts of Canada where an actual power shortage could result. He said that at present, B.C. exports more than three times as much power from the Peace River region in the form of gas than it proposes to sell as downstream hydro power, and he could not understand, he said, why Ottawa condoned the export of one type of power, and opposed the other types. Dr. Shrum estimated that it would cost $427 million before the first power from the Peace River reaches Vancouver, probably in 1968. It will continue to develop irrespective of other parts of the proposed rival developments in B.C.

Regarding possible benefits to Alberta from the Peace River developments, Dr. Shrum said it will help in regulating the flow of the river, thereby aiding in navigation and perhaps enabling Alberta to develop her own power facilities.

ESTEVAN

O. P. Lesiuk, M.E.I.C.

J. Peden, Instructor in Civil Engineering Technology at Moose Jaw Technical School was the guest speaker at the April 1 meeting. Mr. Peden spoke on problems pertaining to organization and qualifications which would be encountered in affiliation with the Association of Professional Engineers. Mr. Peden outlined the reasons for the proposed affiliation of technicians with the A.P.E.S., and discussed the benefits it would provide to technicians as well as to the engineers. He said the major problem to overcome would be that of deciding the qualifications of technicians for membership in the association. A proposed application form was distributed and the various classes of qualification were discussed.

A report on the Saskatchewan meeting of the Council of the Engineering Institute of Canada was given by A. Guthrie. The Institute's library, finances, confederation and the statuses of the various branches were discussed at the Council meeting.

A talk by Bill Hewes on corrosion has been planned for the next general meeting of the Branch.

MOOSE JAW

R. J. Tomlinson, M.E.I.C.

E. J. Cole, City Engineer for the City of Saskatoon, was the guest speaker at the Branch's April 24 Meeting.

In his talk, "The Engineer and his Effect on Present Living Conditions", Mr. Cole outlined the living conditions of fifty years ago, and compared them to those of today, emphasizing the many conveniences available today. He said that everyday use of these conveniences has made the public apathetic towards them. The true value of these conveniences is only realized when a disruption in their extension occurs. Then, the public becomes aroused and protests the lack of service. Mr. Cole said the engineering profession should be responsible for the education of the public regarding the problems which may arise in the distribution of public utilities. An effort to eliminate these problems should be made.

A smorgasbord dinner was held prior to Mr. Cole's address, and it was followed by entertainment and a social evening for members and their wives.

NEWFOUNDLAND

Anthony Nemec, M.E.I.C.

The Branch held its annual dance April 27 at the Old Colony Club. The Slide-Rule Ball was the name given to this function, and all who attended had an enjoyable time. Decorations included hundreds of balloons and slide rules. The Silhouettes provided musical entertainment and refreshments were served.

NIPISSING AND UPPER OTTAWA

J. S. Cooper, M.E.I.C.

The Annual Meeting of the Branch was held at the Golden Dragon Restaurant in Ferris on May 2.

Chairman R. A. Booy presided, and 22 members and guests were present. Following dinner, the reports of the various committees were read. These reports indicated that the Branch had had a successful year. The report of the nominating committee was read, and the following officers were elected by acclamation: Chairman, P. M. Rebin of Sturgeon Falls; Vice-chairman, D. P. Duffy, North Bay; Past-chairman, R. A. Booy, Temiscaming. The executive committee will include: D. R. Catford, Temiscaming; M. Felix, Temiscaming; E. Capstick, North Bay; D. W. Briden, North Bay; P. M. Rebin, Sturgeon Falls and L. Blais, Kirkland Lake.

After the business meeting, two excellent films were shown. The films supplied through courtesy of Remington Arms were "Exhibition Shooting" and "Gunning the Flyways".

PETERBOROUGH

Tod Willcox, M.E.I.C.

On February 16, the Branch celebrated the 75th Anniversary of the Engineering Institute of Canada with a diamond jubilee ball held in the Imperial Ballroom of the Empress Hotel. A buffet of oriental foods was served. Displays of engineering accomplishments throughout the years created an atmosphere in keeping with the theme of the evening.

The February dinner meeting was held at the Kawartha Golf and Country Club with Henry Aurand Jr., of the General Electric Company of Santa Barbara, Calif., as guest speaker. Mr. Aurand spoke on cybernetic anthropomorphous machines. A report was given on the progress in developing machines which can function similarly to a human being for use in space exploration and other hazarous activities. The principal feature of recently developed machines is that they are capable of amplifying muscular ability, and are equipped with force and visual feedbacks systems to enable the operator to sense what he is doing. Mr. Aurand demonstrated how difficult it was for an operator to manipulate a machine in two dimensions without feedback control, and how easy it was to operate in three dimensions with force feedback.

In March a dinner was held in conjunction with an Institute-sponsored Atomic Exhibition. The guest speaker was J. L. Gray, President of Atomic Energy of Canada Limited. Mr. Gray reviewed the atomic power program in Canada and presented his current assessment of the impact of atomic power on industry in the future. The Atomic Exhibition held March 28 and 29, by the Branch focused attention on the

(Continued on page 80)

News of the Branches

(Continued from page 79)

role that Peterborough engineers have played in Canada's atomic power industry. The exhibition was held in the Imperial Ballroom of the Empress Hotel and was attended by 1100 high school students and teachers, and over 1500 from the general public. The Exhibition consisted of working models of the NPD, CANDU and NRX reactors, a Cobalt-60 Therapy unit, cloud chamber, ultrasonic testers, air gages and Vidigage testers. Display panels showed samples of various uranium ores and the numerous compounds produced in the process of making fuels for reactors. The displays were provided and staffed by Canadian General Electric and Atomic Energy of Canada Limited.

The President's annual visit was held on April 24. Dr. B. G. Ballard met with Branch executive during the afternoon, while Mrs. Ballard was entertained by the members' wives. A dinner meeting was held in the evening at the Kawartha Club after which Dr. Ballard gave a progress report on Confederation.

The Branch Executive for 1962 consists of: Bill Durant, Chairman; Peter Tuck, Past Chairman; Bob Rehder, Secretary Treasurer; Don Lamont, Councillor; Bill Cliffe, Technical Meeting; Ron Doughty, Social Events; Peter Thompson, Membership; Ted Willcox, Publicity and Public Relations; John Bright, Representative to APEO and Barry Ottlewell, Historian.

QUEBEC

Rene Rioux, M.E.I.C.

L'assemblée annuelle de la section de Québec s'est déroulée au Cercle Universitaire Laval le 12 mars. A cette occasion, les membres ont eu le privilège d'entendre M. Louis-P. Bonneau, M.E.I.C., vice-recteur de l'Université Laval, qui nous a fait part des problèmes que suscite l'expansion de l'Université. Notre invité d'honneur fut présenté par M. Lionel Boulet, M.E.I.C., directeur du département de génie électrique, et remercié par M. Bernard Michel, M.E.I.C., directeur du département de génie civil.

Le nouveau conseil du chapitre de Québec sera formé ainsi: Président, Jean-Baptiste Delage; Vive-Président, Jacques Roy; Secrétaire-trésorier, Jacques Plamondon; Conseillers, Jean-Louis Bourret, Marcel Jobin, Bernard Michel, Marc Bergeron, Paul Bousquet, André Gagnon; Anciens présidents, René Rioux, B.-I. Burgess, Pierre Duchastel.

Le 12 avril, au Club Cambrai, en collaboration avec le chapitre local de la Corporation des Ingénieurs Professionnels, plusieurs de nos membres ont accepté d'être parrains pour les étudiants qui recevaient leur anneau de fer. Cette soirée, qui réunissait au-delà de 100 étudiants et autant d'ingénieurs, fut marquée par la franche camaraderie qui s'est vite établie entre les ingénieurs présents et leurs confrères de demain.

SARNIA

L. J. Archibald,

On May 15, the Branch held a joint meeting with the local branch of the Chemical Institute of Canada. The meeting was well attended, and the guest speaker, D. J. McDonald, Aero Radio Engineer with the Bell Telephone Company, provided a very informative talk on "Satellite Communications". Since the installation of microwave following World War II, the Bell Telephone Company, along with others, has been doing considerable research in the possibilities of world-wide microwave transmission by the use of satellites. A lively question and answer period followed the talk.

In the absence of the Branch Chairman, C. R. Young, Vice-Chairman, R. W. Hodgson conducted the meeting.

UNIVERSITY OF WESTERN ONTARIO

David Fader

A student paper contest was held March 27 and April 3 at which members of the graduating class presented papers on projects which they had completed during the year. Four finalists were selected. They presented their papers on April 10 before a panel of three judges: Dean R. M. Dillon, Dr. E. V. Buchanan, Chairman of the Engineering Science Advisory Committee; and G. Chorley.

The contestants and the papers they presented are as follows: G. Steels, Model Study of Wind-Induced Vibration in Guy Wires; J. Westeinde, Bundle Reinforcement in Concrete; J. Howard, Investigation of Inferential Metering; J. MacArthur, Heat Transfer Between a Vertical Heating Element and a Fluidized Air-Solid Mixture. The winner of the Engineering Institute of Canada's Best Paper Award was J. MacArthur.

VICTORIA, VANCOUVER ISLAND

W. N. Tivy

A reception and dinner honoring Dr. B. G. Ballard, President of the Engineering Institute of Canada, and Mrs. Ballard was held May 12 at the Victoria Art Gallery.

In his address, Dr. Ballard outlined the varied opinions held by members and Branches across Canada regarding Confederation. In his opinion, the various branches of engineering have made the greatest contribution of all professions to the development of Canada. He gave examples to substantiate this claim. Dr. Ballard spoke of the advantages resulting from improved relations between the scientists of the U.S.S.R. and scientists of the West. He also discussed the improvement in communications with the use of satellites.

A tour of the gallery terminated the enjoyable visit.

Library Notes

Prepared by the Library, The Engineering Institute of Canada

Book notes marked by an asterisk have been provided through the courtesy of The Engineering Societies Library in New York.

BOOK REVIEW

*PRINTED CIRCUITS

Printed circuit techniques are discussed with particular emphasis on circuit and equipment design. Following a brief description of manufacturing processes, the author considers the preparation of the circuit information, materials for printed circuits, printed components for low and medium frequencies, strip transmission lines, and printed microwave systems. Appendices describe testing procedures and specifications as well as some early printed circuit patents. (J. M. C. Dukes. London, Macdonald, 1961. 228p., £2.)

ARCHES: TABLES FOR STATICAL ANALYSES.

These tables are intended as an aid in calculating the magnitude of the normal forces and bending moments of the various cross-sections of statically indeterminate arches. To simplify the calculations, the main tables for the vertical and horizontal components of reactions are supplemented by auxiliary tables giving the magnitudes of normal forces and bending moments for cases most frequently met with in practice. The notes and legends on the tables are given in English, German, Polish and Russian. The compiler is at the Technical University of Warsaw. (Jan Szymczyk. London, Pergamon, 1961. 536p., $20.00.)

THE WORLD OF LEONARDO DA VINCI.

A picture of Leonardo da Vinci as a scientist, and a civil, military and mechanical engineer, set against the background of the Italy of his time.

There are many illustrations, including some from Leonardo's Notebooks. (I. B. Hart. London, Macdonald, 1961. 374p., 45/–.)

*COEFFICIENTS FOR ANALYSIS OF TWO AND THREE-SPAN CONTINUOUS BEAMS OF CONSTANT MOMENT OF INERTIA.

This volume, with tables covering up to 215 span ratios, provides a quick direct reference for those concerned with the structural design or investigation of continuous beams. The tables include load conditions which seem to cover most of the practical problems met in structural engineering. They enable either an exact or an approximate analysis of such problems as the dead load analysis of bridge stringers, the comparison and design of floor systems and building beam analysis and design. Used directly, without recourse to influence lines, they provide a quick, complete analysis of beams subjected to complicated loading conditions if the principle of superposition is applied properly. (Muscatine, Iowa, Stanley Engineering Company, 1961. 229p., $12.50.)

MANUAL OF FIELD GEOLOGY.

Intended primarily to help undergraduate students with their field training, this text assumes that the reader can identify common rocks and minerals, and is acquainted with geologic structures and the basic principles of stratigraphy. (R. R. Compton. New York, Wiley, 1961. 378p., $7.50.)

THE ENGINEERING INSTITUTE LIBRARY

The publications mentioned in these notes are now available in the Library, and may be borrowed by members of the Institute. Two items may be borrowed at one time for a period of two weeks, excluding time in transit.

Library hours are: Monday to Friday: 9 a.m. to 5 p.m. All requests and enquiries should be addressed to the Librarian at 2050 Mansfield Street, Montreal.

*BRITISH ELECTRICAL POWER CONVENTION, THIRTEENTH. PROCEEDINGS.

These proceedings center about the theme, "Electricity in the Prosperity and Welfare of the Nation." They discuss the British electricity transmission system, some aspects of efficiency and economy in distribution, the electrical power industry in Canada, and British electrical manufacture in the national economy. (London, the Convention, 1961. 391p.)

INTERNATIONAL ASSOCIATION FOR BRIDGE AND STRUCTURAL ENGINEERING, SIXTH CONGRESS, FINAL REPORT.

This final report of the sixth congress of the association, held in Stockholm in June 1960, contains most of the papers presented during the working sessions. The papers were divided into six sessions. (Zurich, Leemann, 1961. 521p., 66 SFr.)

LINEAR PROGRAMMING.

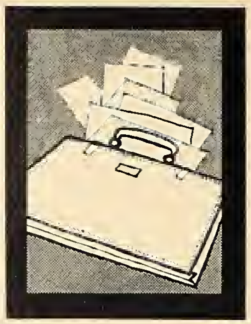
This volume presents a fairly rigorous development of the theoretical and computational aspects of linear programming, as well as a discussion of some practical applications. Familiarity with linear algebra and convex sets is assumed, although the mathematical background needed is covered in the second chapter. (G. Hadley, Reading, Mass., Addison-Wesley, 1962. 520p., $9.75.)

*ASHRAE GUIDE AND DATA BOOK, 1961.

This first of two volumes of a standard reference work deals with fundamental theory and equipment relating to heating, refrigeration, ventilating, and air conditioning. Extensive revisions of material taken from previous editions and the addition of 23 new chapters bring the subject matter up-to-date. The second volume will deal with current practice in specific applications. (New York, American Society of Heating, Refrigerating and Air-Conditioning Engineers, 1961. 406p., $12.50.)

(Continued on page 89)

Business and Industrial Briefs



Appointments and Transfers

E. R. Stillings

Andre Desarzens

E. R. Stillings has been appointed Production Manager of Leeds & Northrup, Canada, Limited in Toronto. Mr. Stillings brings to his new position wide experience in the field of electronic instrumentation and controls in steel, automotive, ceramics, power and other industries.

Andre Desarzens has been appointed Regional Manager by Eutectic Welding Alloys Corp. Mr. Desarzens will have his headquarters at Sillery, Que., and will supervise the company's service, sales and educational program for industry and governments in Eastern Quebec and the Maritime Provinces. Mr. Desarzens's region will embrace eight active technical representatives serving the lumber, mining and paper belts, as well as the farm implement, building product, metals, refining, shipbuilding and other industries.

J. C. Gleason has been named district manager, Halifax, for Canadian Allis-Chalmers Limited. Mr. Gleason brings to his new position many years of sales and management experience relating to the pulp and paper, mining and refining industries.

George E. Merryman, Jr. has been appointed manager of the Montreal East plant of Union Carbide Canada Limited's Chemicals and Plastics Division. Mr. Merryman joined the company in 1942, and in 1959 was appointed assistant plant manager at Montreal East.

George M. McGregor has been appointed General Manager of Donald Ropes and Wire Cloth Limited. Mr. McGregor was formerly Assistant General Manager.

C. P. Baker has been named executive vice-president and general manager in charge of Mannix Co. Limited's Canadian activities. Mr. Baker joined the company in 1950 and has been engaged on various large construction projects. He was for a time the company's Pacific Coast representative, and just prior to his recent appointment was general manager of construction divisions.

C. P. Baker

P. G. McLaren

P. G. McLaren, retired recently from the RCAF with the rank of Wing Commander, has joined the staff of the Canadian Highway Safety Council in Ottawa. He will direct the reactivation of the National Safety League of Canada.

P. Pemberton Pigott has been appointed to head mechanical engineering development at Product Design Unit of Stewart & Morrison Limited. Mr. Pigott will be responsible for all engineering development of new products. Mr. Pigott was formerly with Ontario Hydro engaged in the design of major mechanical equipment for hydraulic power stations. Between 1954-58, he was responsible for the design, purchase and co-ordination of mechanical equipment for the St. Lawrence Power Project. Earlier, he designed the draining power tunnels below Niagara Falls.

George M. McGregor

John D. Hopping

John D. Hopping has been named General Sales Manager for Canada by the Rover Motor Company of North America Limited, Toronto. Formerly Parts and Service Manager, Mr. Hopping has been associated with Rover since 1957 when he joined the company in England as a member of the Technical Service Department.

Patrick M. Draper has been appointed Vice-President, Administration, Canada Iron Foundries, Limited. Mr. Draper joined the company in 1952 and has held a number of senior positions, most recently that of General Manager, Pressure Pipe Division.

P. Pemberton Pigott

Patrick M. Draper

A. A. (Bert) Castle has been appointed Service Manager of the Sept Iles Branch of Hewitt Equipment Limited, Quebec dealer for the Caterpillar Americas Company. Mr. Castle has had a wide range of experience in the equipment field and has been well trained in all phases of Caterpillar equipment.

(Continued on page 103)

• Library Notes *(Continued from page 82)*

TABLES OF INTEGRALS AND OTHER MATHEMATICAL DATA, 4th ed.

This collection of tables and formulae has been compiled from many sources, and these are listed in both the text and bibliography, so that interested readers may check the derivation of the results, and locate similar results. A useful index is also included. (H. B. Dwight. Galt, Brett-Macmillan, 1961. 336p., $3.50.)

TOWARDS INFORMATION RETRIEVAL.

The author has been concerned with the problems of information retrieval for many years, and the papers in this collection have been written over the last fifteen years, and are concerned with the principles of the subject, rather than the techniques of problem solving. (R. A. Fairthorne. Toronto, Butterworth, 1961. 211p., $6.50.)

GLASS REINFORCED PLASTICS, 3rd ed.

Enlarged and revised this third edition includes new chapters on dough moulding compounds, glass reinforced sheeting, and filament winding as applied to pressure vessels. The various chapters are written by experts in the field, and the book is edited by the Editor of British Plastics. (Ed. by Phillip Morgan. London, Iliffe, 1961. 340p., 50/-.)

PRACTICAL METROLOGY, VOL. 4.

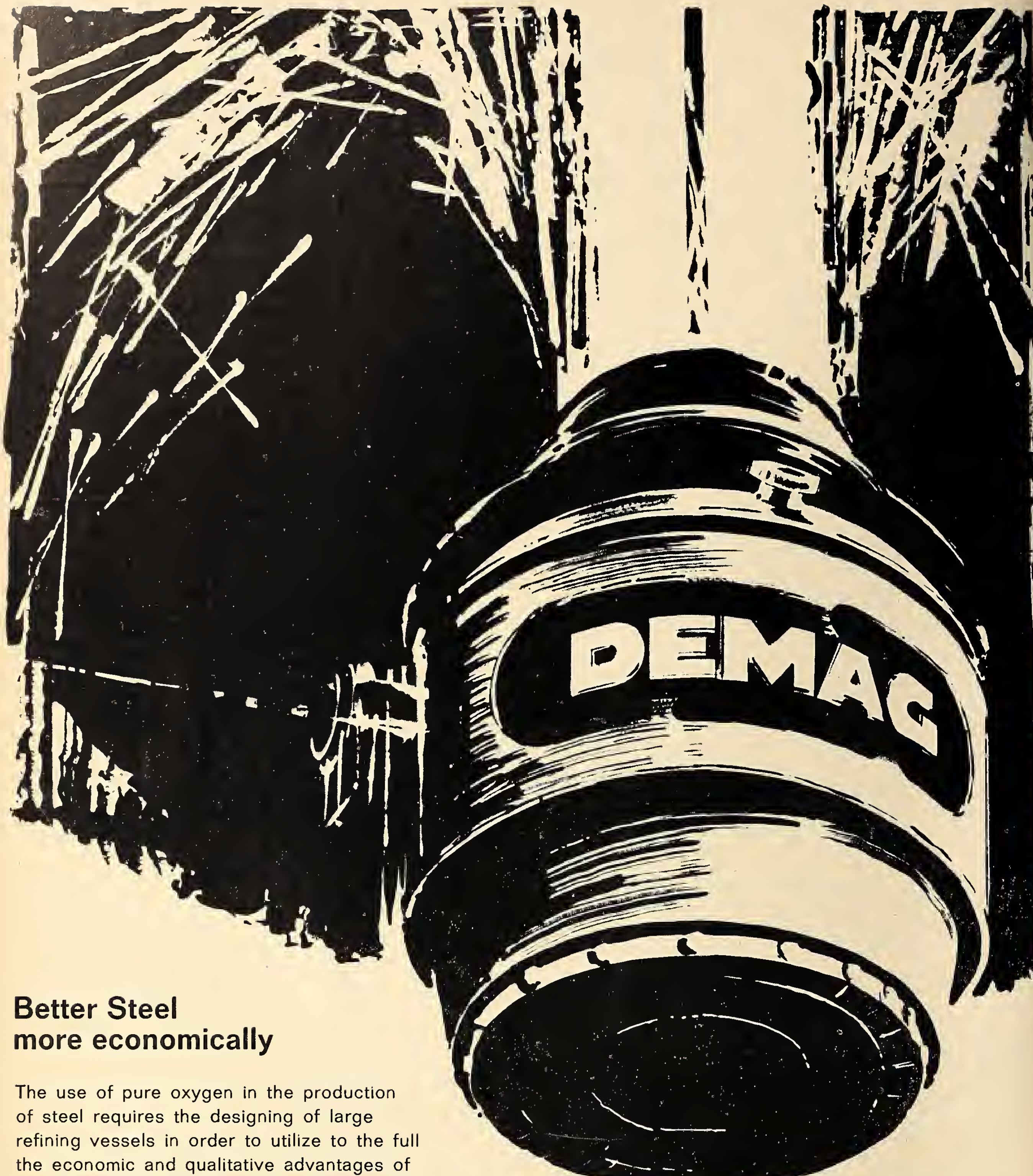
The seven experiments described in this volume require a more advanced stage of study than those in the first three volumes, and they deal with measurements of length and angle to the highest accuracy usually reached in engineering metrology laboratories. (K. J. Hume and G. H. Sharp. London, Macdonald, 1962. 61p., 7/6.)

CALCUL SIMPLIFIE DES POUTRES CONTINUES DES PLANCHERS MODEREMENT SURCHARGES.

In France, regulations for the use of reinforced concrete permit two methods of calculation for continuous beams, one by Caquot's method, and the other by the "règle forfaitaire" for floors with a moderate load.. The authors, consulting engineers, covered Caquot's method in a previous volume, and in this deal with "rules B.A. 60". (M. and A. Reimbert. Paris, Eyrolles, 1961. 155p., 25.35 NF.)

*LES TRAITEMENTS DE SURFACE ET LA FINITION DE L'ALUMINIUM ET DE SES ALLIAGES.

Translated from the second English edition, this volume is a comprehensive and up-to-date review of processes for the surface treatment and finishing of aluminum and its alloys, with an introductory chapter on history, development and corrosion. The composition and properties of major British and U.S. aluminum alloys are given in appendix tables. (S. Wernick and R. Pinner. Paris, Eyrolles, 1962. 597p., 91.35 NF.) *(Continued on page 96)*


DEMAG

Discussion

(Continued from page 47)

8. Effect of Creep

Great care is taken in conducting tests to allow time for creep to occur, particularly in cases where instability is important. It is recognised that testing conditions, under which loads are gradually increased, but never decreased, until failure takes place, are highly artificial and not at all representative of real conditions. In a structure, subjected to decreasing as well as increasing loads, creep occurs only at the maximum loads in a sequence of loads. Actual structures, subjected to loads beyond the elastic limit, will creep only during a period when the load is higher than any previously applied load. It is therefore misleading to claim that creep is of central importance in the behaviour of structures beyond the elastic limit. The effect of creep on the failure load of a structure is of no greater order than the effect of natural variations in yield stresses, and will be allowed for by the usual practice of taking a lower limit for the yield stress, corresponding to a very small rate of creep.

9. Frame Instability

This is a subject which is now receiving considerable attention. Sufficient is now known[4] to enable those structures which are likely to show any significant reduction of carrying capacity due to frame instability to be identified. For a remarkably wide range of structures, it is found that strain-hardening compensates completely for frame instability.

10. Plastic Design and Plastic Analysis

Professor Hrennikoff states that non-rigid, as opposed to rigid, plastic theory deals only with design and not analysis. This is not really so, except possibly for the case that deflexions *may* become critical for any given structure. If deflexions are so large that the basic equilibrium equations are disturbed, then it is true that the simple plastic method can not be used to give a completely accurate value for the load factor against collapse. If, however, deflexions are within the normal structural tolerances, then, in general, the predicted load factor will be correct.

But, if plastic theory will not "work" for a particular structure because deflexions are large, then neither will elastic theory. There is no simple elastic method of analysis known to us which can accommodate gross disturbance of equilibrium equations; the full equations must be written, and probably solved on an electronic computer. Once again, the problem is not one of plastic versus elastic theory, but of whether the structural model accurately represents reality.

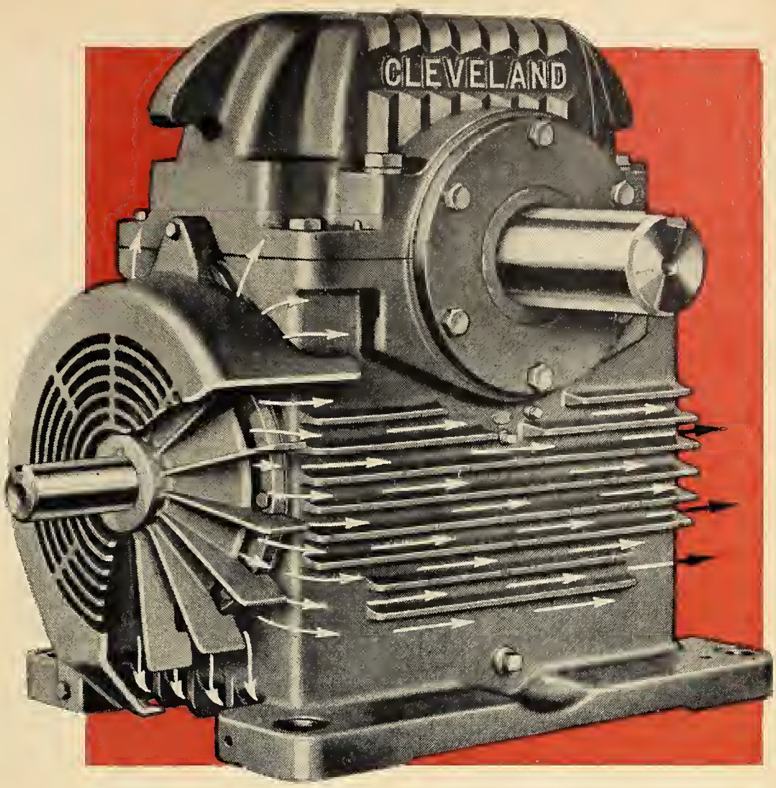
12. Loading Conditions

The author quotes a case in which the removal of the live load from a beam after the beam has been subjected to the full live plus dead load results in the aggravation of a column loading condition. He argues that the probability of such a sequence is the same as the application of the load in the first place. It is to be noted however that the full carrying capacity of the beams having been reached, the structure has in fact "failed" under the first load application. The tracing of the subsequent behaviour of the frame is therefore of no significance.

It is acknowledged that the load factor criterion is not of itself satisfactory — it is simply the expression of an overall factor of safety. The "collapse load" condition is a fictitious one, since is in fact assumed that it will not be reached during the life of the structure. It is equally true however that the "working load" used in ordinary design is an abstraction, and is again a complex function of safety

(Continued on page 94)

Fan cooling for Increased HP Capacity is Not New ... *to users of Cleveland Speed Reducers*



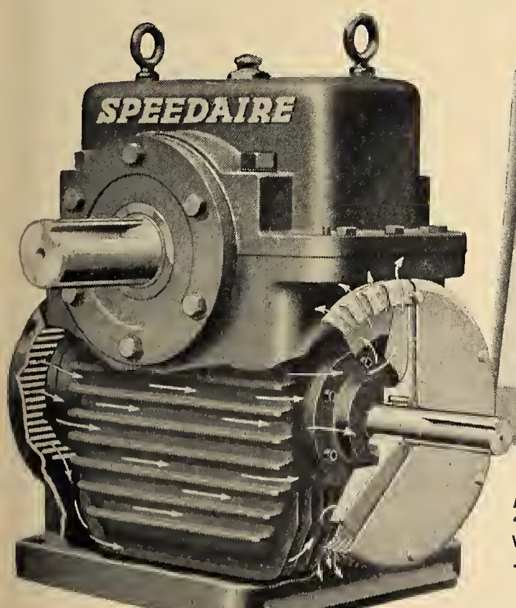
As far back as 1944, Cleveland Speedaire Worm Gear Reducers (shown in both the announcement ad and cutaway photo below) were providing industry twice the load carrying capacity then available from standard worm gear units of equal frame size. Even then, it was *fan cooling* that did the trick—because fan cooling was and still is the most practical method of heat dissipation.

On the new, higher horsepower Cleveland's (shown in top cutaway photo), a small, specially designed fan—equally effective in either direction of rotation—is located on the worm shaft's input side. Fan size and design permit a smooth, more effective flow of air beneath, above, and around all sides of the reducer.

Mounting the cooling fan on the worm shaft INPUT end is a very definite Cleveland advantage for when the fan is mounted on the *opposite* side, a second oil seal is needed. This results in additional friction loss due to seal drag—and is another point where oil leakage could occur.

Remember, it was Cleveland design engineers who pioneered both fan cooling and centrifugal casting of bronze gears—and after sixteen years of rugged field usage in all types of industrial plants, have now incorporated these features in all units (from 3 to 12-inch centers) of the new standard Cleveland Speed Reducer line.

Get the story of these new speed reducers from your Peacock representative, or write today for free 36-page illustrated Bulletin No. 420 that contains complete engineering information. Either way, you will get the answer to improved speed transmission — at savings of 50% or more on per horsepower cost!



A 1944 CLEVELAND AD
"Announcing A Fan-Cooled Worm Gear Speed Reducer . . . SPEEDAIRE."

CLEVELAND
Worm Gear
Speed Reducers

PEACOCK BROTHERS LIMITED
P.O. Box 1040 • Montreal 3, Quebec

• Discussion

(Continued from page 92)

criteria. The advantage of the load factor method is that the resistance of the structure is correlated directly with a real material property — the yield stress. The "safe stress" used in combination with "working loads" is itself an obstruction — and the safety of the structure depends not on one obstruction, but on two. The load factor approach is more rational than the safe stress approach, and this is demonstrated by its increasing adoption in structural design quite apart from its use in connection with the plastic theory.

14. Advantages vs. Disadvantages of the Plastic Theory

Professor Hrennikoff states that plastic theory claims to give (a) simplicity of design, (b) a more realistic factor of safety, and (c) better economy. He denies these claims for other than simple structures not subject to instability.

When buckling may occur, plastic theory becomes less simple. But it does not become complex compared with an elastic theory aiming for the same realistic factor of safety; it becomes complex only compared with simple plastic theory. The problem must be stated in the right terms. If the designer wishes to design a structure realistically, and economically, then the design method may become complex; plastic theory is essentially realistic, and hence almost inevitably economical. While elastic theory may be rational as applied to the idealised model of the structure, elastic design as applied to the real structure becomes largely a collection of empirical formulae; the more empirical the formulae, the less realistic will be the design, and the worse the economy.

Plastic theory attempts, above all, to stand fast by realism; as more complex structures are designed, so the theory becomes less simple. But, at the first sign of heavy weather, elastic theory throws realism overboard, in an attempt to conjure the zephyr calm simplicity; and simplicity is the treacherous song the Sirens sing. EIC

• Library Notes

(Continued from page 89)

*INFLUENCE LINES FOR CONTINUOUS BEAMS ON ELASTIC SUPPORTS.

Equations, tables, and graphs are presented for the reactions of continuous beams on elastic supports. Beams with constant sections only are covered. Information for beams of constant span length from two to twelve spans is given. Influence line data is also given for variable span lengths for two, three, and four span beams. All tables give eight place values, and are sufficiently accurate to develop influence lines for moment and shear at any point along the beam with sufficient reliability. (D. A. Firmage and R. H. Chiu. Provo, Utah, Brigham Young University, 1961. 475p., $10.00.)

*TOTAL QUALITY CONTROL: ENGINEERING AND MANAGEMENT.

Quality control is reviewed in depth from the point of view of business operations and the kinds of engineering activities that must be carried on. Details are presented on how to plan a quality control system, set up a suitable organizational structure, integrate the various functional activities, engineer the necessary plans and controls, and measure the result in terms of costs and product quality levels. A revised edition of the 1951 publication Quality Control. (A. V. Feigenbaum. Toronto, McGraw-Hill, 1961. 627p., $11.55.)

*POLYMERIC MATERIALS.

The chemical, physical, and engineering principles and applications of polymer materials are presented in a comprehensive fashion. Beginning with polymer chemistry, molecular structure, and properties, the authors continue with fabricating methods and applications, all involving fundamentals common to a large number of different polymers. Specific commercial polymers are then discussed in detail. (C. C. Winding and G. D. Hiatt. Toronto, McGraw-Hill, 1961. 406p., $12.60.)

*DER STAHLHOCHBAU, VOLUME 1, 7TH. ED.

Following an introductory chapter on classification of various types of steel, their strength, and treatment, the author provides detailed information on the design and construction of different kinds of beams, columns and structural frameworks. There is a separate section on connecting methods in steel buildings: bolts, rivets, welding, double-butt strap joints, etc. The appendix includes numerical tables and examples. (Ed. by Werner Tramitz. Berlin, Ernst, 1961. 297p., DM 39.60.)

*DIE KREISELPUMPEN FUR FLUSSIGKEITEN UND GASE.

This well-known work on centrifugal pumps has again been considerably revised and enlarged to include the latest results of hydrodynamics research and practice. It covers both liquids and gases, and in addition to pumps, deals with ventilators, blowers, and compressors. A comprehensive review of both theory and design, the book is well suited to the needs of practicing engineers. (Carl Pleiderer. Springer-Verlag, Berlin, 1961. 622p., DM 61.50.)

STRUCTURAL PROCESSES IN CREEP.

The report of a symposium held in May 1961 by the Iron and Steel Institute and the Institute of Metals, containing the fifteen papers presented, as well as the discussion they aroused. The aim of the symposium was to bring together those interested in fundamental research, and those interested in the practical aspects of creep. The first session covered more general aspects of creep, such as stress sensitivity, the relation between creep and fracture, and grain boundaries. The second session was devoted to creep in various alloys, while the third was concerned with creep in steel. (London, Iron and Steel Institute, 1961. 351p., 65/-. I.S.I. special report no. 70).

(Continued on page 98)

New Brunswick combines SOIL-CEMENT and "Paving Train" technique to complete 2 MILES of roadway A DAY!

Two graders work side by side shaping windrows for processing by road mixers.

Powerful Pettibone-Wood road mixer (above) advancing down windrows. Roadway material, cement, and water are mixed by steel arms in mixing chamber, road out behind.

Compacting and levelling of location with 10-ton pneumatic roller (below).

This co-ordinated operation, using tandem road-mixers and graders, enabled New Brunswick's Department of Public Works to lay soil-cement paving of 5″-7″ thickness at the rate of at least two miles each ten-hour day. A 5½% cement content mix was used to build this low-cost, provincial-standard roadway. Frost-withstanding soil-cement made with Canada Cement grows stronger with the years, can save time and money on roads built for light traffic.

Minister of Public Works: **Hon. A. F. Richard**
Deputy Minister: **W. T. Hargreaves**
Chief Highway Engineer: **R. W. Manzer**

For technical and other information, just attach publication list below to your letterhead and mail.

SOIL CEMENT CONSTRUCTION HANDBOOK • CEMENT TREATED SUBBASE
SOIL PRIMER • SOIL CEMENT LABORATORY HANDBOOK
ESSENTIALS OF SOIL-CEMENT CONSTRUCTION, INSPECTION FIELD CONTROL
SOIL-CEMENT LOW COST PAVEMENT FOR PARKING AND STORAGE AREAS
SOIL-CEMENT SHOULDERS FOR MODERN HIGHWAYS

CANADA CEMENT

Canada Cement Company, Limited

PHILLIPS SQUARE, MONTREAL, P.Q.

SALES OFFICES: MONCTON • QUEBEC • MONTREAL • OTTAWA
TORONTO • WINNIPEG • REGINA • SASKATOON • CALGARY • EDMONTON

• Library Notes

(Continued from page 96)

FRANK LLOYD WRIGHT

The biography of a man who played such an important part in American architecture for almost sixty years, this volume tells of his early struggles and personal tragedies, as well as his professional achievements. In all he designed nearly 700 buildings, and illustrations of many of them are included. (Finis Farr. Toronto, Saunders, 1961. 293p., $7.50.)

SHIP HULL VIBRATION.

Intended for the practical naval architect and shipbuilder, this text is confined to a discussion of the vibration of ships' hulls. Introductory chapters cover the vibration problem as it concerns ships, the types of vibration and their causes, and the mathematical basis of the problem. The methods of estimating hull frequencies be detailed calculation and empirical formulae are described, and compared with measurements made on actual ships. The various methods of preventing and curing hull vibration are covered, including changes to propeller design, the use of vibration dampers, neutralisers and elastic mountings. The use of computers in calculating vibration frequencies is discussed, and the available data on recorded cases of ship hull vibration are included. There is also an extensive bibliography. (F. H. Todd. Toronto, Macmillan, 1961. 364p., $18.90.)

***DEVELOPMENTS IN MECHANICS, VOL. I.**

These are papers given at the Seventh Midwestern Mechanics Conference, a combination of the Seventh Midwestern Conference on Fluid Mechanics and the Fifth Midwestern Conference on Solid Mechanics. (Ed. by J. E. Lay and L. E. Malvern. New York, Plenum, 1961. 622p., $21.00.)

***MECHANICAL BEHAVIOR OF ENGINEERING MATERIALS.**

The microscopic stress-strain behavior of materials under various environments encountered in modern engineering applications is presented in this text. A considerable amount of important new material is included, and numerous references are given. (Joseph Marin. Englewood Cliffs, Prentice-Hall, 1962. 502p., $15.00.)

***HYDRAULIC EXTRUSION PRESSES.**

An English translation of a 1959 German publication, this volume deals with the basic principles for determining the rating and design features of extrusion presses for the manufacture of tubes, cable sheathing, rods and wire in nonferrous metals. It also traces the development and improvement of both extrusion techniques and machinery. Some practical examples are also included. (Ernst Muller. Berlin, Springer, 1961. 257p., DM 39.60.)

LES ACHATS: SOURCE DE BENEFICES.

Originally published by the American Management Association under the title Purchasing for Profit, this volume emphasizes the importance of the Purchasing Department to a company. (Paris, Dunod, 1962. 113p., 11 NF.)

***REPORT ON PHYSICAL PROPERTIES OF METALS AND ALLOYS FROM CRYOGENIC TO ELEVATED TEMPERATURES.**

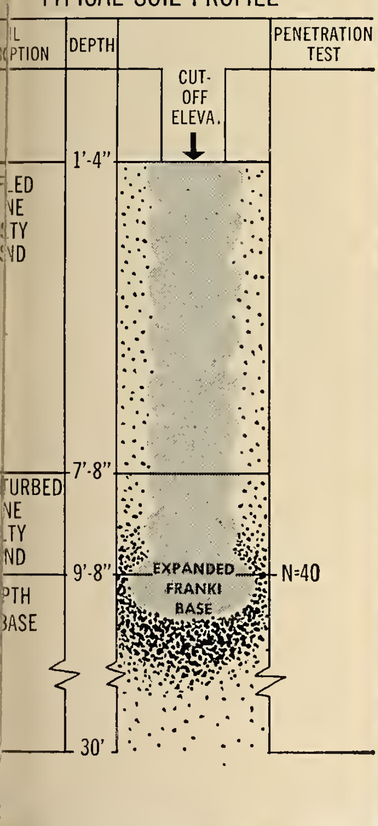
Physical-property data of six metals and their alloy systems are given, specifically, aluminum, cobalt, iron, magnesium, molybdenum, and nickel. Data are given on thermal conductivity, linear thermal expansion, specific heat, electrical resistivity, density, emissivity, diffusivity, and magnetic permeability. Emphasis is given to data over a range from cryogenic (−457°F) to elevated temperatures (4500°F). (Philadelphia, American Society for Testing Materials, 1961. 206p., $4.75. s.t.p. no. 296.)

(Continued on page 100)

RANKI
ACTS

:
o Calgary
IC:
a N.W., Alberta
TE S AND ENGINEERS:
nn and Rule, Calgary
A OR:
s Dutton Cancrete & Construction Co.
gary
C SULTANT:
r s Testing Laboratories Limited, Calgary
F TRUCTURE:
t Stadium
F OF FRANKI UNITS:
F ki Caissan-Piles
N LOAD:
o Maximum
C CAISSON — PILES:
a Driven Length 9′ 8″
a Cancreted Length 8′ 4″

TYPICAL SOIL PROFILE



erature-This series of job highlights, as well other descriptive literature, will be sent you upon request to Franki of Canada Ltd., 7 Graham Blvd., Montreal 16, P.Q.

Franki Caissons Beat Spread Footings

Problem:

McMahon Stadium in Calgary was conceived, designed and constructed in a spirit of co-operation. The designers were faced with the problem of erecting a modern athletic stadium in a few months if it was to be ready for the opening game of the 1960 WIFU Season.

The stadium site chosen had natural bowl-like contours and grading proceeded prior to completion of superstructure design. The soil profile indicated fine silty sands of medium density to at least 30 feet. Average grain size distribution was 63% fine sand, 28% silt and 9% clay sizes. Random silt lenses at shallow depths made the soil susceptible to frost action. The maximum column load was 100 kips. Allowable bearing pressure for spread footings was 4000 pounds per square foot.

Solution:

Franki was called to suggest a foundation solution providing speed, economy and guaranteed performance. Short Franki Caisson-Piles — sometimes called pressure-injected-footings — were proposed. The Franki proposal required end bearing concrete bases in the fine silty sand, 2 feet below original grade or 8 feet below finished grade, whichever was greater. At these depths, the average blow count was N=40 and the average moisture content was 5%. One caisson-pile was to be used per column.

A spread footing design was studied and rejected because it did not fill the job need with regard to speed and economy because of the necessity to excavate, shore, form and backfill.

The Franki proposal was accepted. The construction period was greatly reduced, the cost of foundations was lower and carrying capacity and minimal settlement were guaranteed.

As a result, Franki of Canada finished their foundations 10 days ahead of schedule and contributed to the success of the entire project, which was completed on time for the opening game.

FRANKI
OF CANADA LIMITED

Head Office: 187 GRAHAM BLVD., MONTREAL 16, P.Q.

QUEBEC OTTAWA TORONTO EDMONTON VANCOUVER

• Library Notes *(Continued from page 98)*

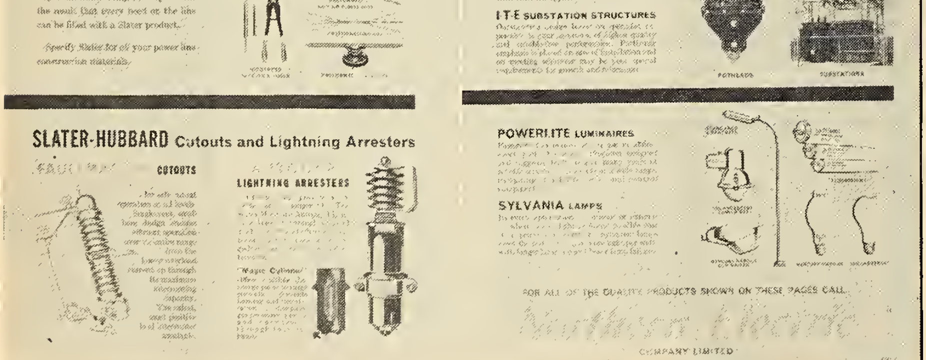
*PRINCIPLES OF ELECTRONIC WARFARE.

"As one fights fire with fire, so electronics weapon systems are now combated with electronic countermeasures; hence, the concept of electronic warfare." This book emphasizes the significance of the electronic elements of the weapon system in supporting the military mission rather than giving detailed analysis of specific systems and pieces of operational equipment. An attempt is made to achieve a balance between the technical and tactical aspects of the problem. Topics treated include: electronic reconnaissance, noise jamming, noise, probability and information recovery, radar considerations, antennas, and space missions communications and reconnaissance. (R. J. Schlesinger, and others. Englewood Cliffs, Prentice-Hall, 1961. 213p., $8.00.)

STRUCTURAL ENGINEERING CONFERENCE, 1961. PROCEEDINGS.

This conference on recent developments in structural engineering was sponsored by the Department of Civil Engineering and the Department of Extension of the University of Alberta. Design and construction in both steel and concrete were covered. Twenty-two papers in all were presented. Those on structural steel emphasized plastic design, but two papers were included on welds and the brittle fracture of steel. The papers on concrete covered both reinforced and prestressed concrete and dealt with such topics as ultimate strength of members, reinforced concrete columns, lift-slab construction, shell roofs, load balancing in prestressed concrete design, and prestressed concrete bridges in Alberta. (Edmonton, University of Alberta, Dept. of Extension, 1961. various paging, mimeog., $8.00.) EIC

EIC CERTIFICATE OF ADVERTISING MERIT



Northern Electric Company Limited wins the Monthly Award for the best advertisement in the April issue of The Journal with the same advertisement that won in October 1961 and February 1962. As we have said before, this serves as acknowledgement of the overwhelming impact of a 5-page insert, to say nothing of the quality of the advertisement itself.

The winning advertisement, headed "Serving Canada's Power Utilities" was a 2-colour, 5-page insert — the odd page being accounted for by the fact that the first sheet of the insert had an extra half-page gatefold. The first page was a title page only; the gatefold featured the men and services behind the products, with the remaining three pages devoted to hard-sell copy and illustrations on a variety of Northern product lines. The second colour, blue (green was used in the October insertion) was effectively used in two shades to make a considerable mass of information appear more readable.

Advertising Manager for Northern Electric Company Limited is E. H. Woodley. The advertising is placed by the Montreal office of Foster Advertising Limited, Frank Thompson, account executive. Both men will receive a framed award certificate. Judging is done each month by a different panel of Journal readers across Canada, with nominations requested on the basis of ACCURACY — INFORMATION — ATTRACTION.

(Continued from page 84)

David W. M. Ross has been elected Vice-President in charge of international operations for Joy Manufacturing Company. He will have his offices at the company's headquarters in Pittsburgh. Mr. Ross has been President of the company since 1958. He joined the Canadian firm in 1945 and has served in various capacities prior to becoming president.

F. H. McLenaghan has been elected President of Burndy Canada Ltd. Mr. McLenaghan joined the company in New York after graduation from Yale University, then returned to Canada in 1949 when the company's Canadian Division was organized. He became general manager of the division in 1952.


F. H. McLenaghan


L. R. Gaiennie

L. R. Gaiennie has been appointed President and General Manager of Howe Richardson Corporation, Clifton, N.J. Mr. Gaiennie is Senior Vice-President and a Director of the Canadian Fairbanks-Morse Company Ltd., Montreal, parent organization of the Howe Corp. The company manufactures a broad line of weighing equipment ranging from mechanical scales through automatic process and materials handling equipment.

R. E. Kidder has been appointed director manufacturing, North America for Massey-Ferguson Limited. Formerly general factory manager of the company's tractor assembly plant in Detroit, Mr. Kidder entered the farm machinery industry in 1945 as manufacturing engineer for Harry Ferguson Inc., Detroit. He joined Massey-Ferguson in 1956. Mr. Kidder's offices will be located in Toronto.

John W. Chapman has been appointed Vice-President and General Manager of Joy Manufacturing Company's operations in Canada. Mr. Chapman has for the past three years, been General Manager of the Craig Bit Co., a Joy controlled company, and will now be responsible for all Joy Canada divisions.

John Kazakoff has been elected a Director of International Power Company, Limited. Mr. Kazakoff has been associated with the company since 1938 and has been an Assistant Vice-President since 1960. He is also a Director and Vice-President of Bolivian Power Company, Limited.

Professor L. G. Soderman of the University of Western Ontario has joined the firm of H. G. Golder & Associates Ltd. as a Director. He will continue his duties at the University and work with the firm as his teaching and research permit.

R. S. Hughes has been named general manager of Union Carbide Canada Limited's Chemicals and Plastics Division. Mr. Hughes succeeds H. L. Reichart, Jr., who became director of production.

G. P. McAdams has been appointed Executive Vice President in charge of Sales, and Assistant to the President at the Josam Products Limited and Affiliated Companies. Mr. McAdams has been with the companies since 1957.

Lucien J. Charton has been appointed secretary of the Canadian Division, Compressed Gas Association, the technical association of companies in the compressed gas and associated industries. Mr. Charton, retired from Canadian Liquid Air Company Limited after 45 years service.

Lyman C. Thunfors has been elected a member of the Board of Directors of Jenkins Bros. Limited. Mr. Thunfors is also Vice-President and Director of the company's branch in New Jersey.

Samuel Fingold has been appointed a Director, Chairman of the Board and President of the Slater Steel Industries Limited. Other company appointments include: L. N. Watt, Director and Vice-President of the Board; H. W. Owens, Director and Executive Vice-President; W. S. Craig, Director and President of the Stamped and Enamelled Ware Division; Harvey Fingold, Vice-President and Comptroller; R. A. Kingston, Secretary and J. S. Spearing, Treasurer.

William F. Lewis has been elected chairman of the board of directors of Montreal Locomotive Works, Limited. A former president of the company, Mr. Lewis is executive vice-president and director of Alco Products Inc., New York. Mr. Lewis first became associated with Alco Products, MLW's affiliate in the United States in 1934.

A. Pawliuk has been appointed manager of manufacturing at Canadian Westinghouse's distribution apparatus division. Mr. Pawliuk has held several manufacturing supervisory posts, the most recent being general superintendent at the London, Ont., plant of the company. R. A. Gilmour has been appointed product sales manager at the division. Mr. Gilmour was previously marketing supervisor.

Consulting Services

Denotes Membership of a Principal in the Association of Consulting Engineers of Canada

Consulting Services

RACEY, MacCALLUM and ASSOCIATES LIMITED
A company owned and operated by
CONSULTING ENGINEERS
Civil, Electrical, Mechanical
Metallurgical, Soils
MONTREAL TORONTO OTTAWA

RIPLEY, KLOHN & LEONOFF LTD.
Consulting Engineers
Soil Mechanics and Foundations
1930 WEST BROADWAY VANCOUVER 9, B.C.

S. E. M. PROSPECTING LIMITED
Depth to bedrock determination by the
SEISMIC REFRACTION METHOD
for
Dam and Power Station locations: Rock Tunnels: Harbour Constructions and Canals: Larger Building Sites, etc., etc.
506 St. Catherine Street E., Montreal 24
Phone: VIctor 9-9252

Stadler, Hurter & Company
CONSULTING ENGINEERS
Municipal, Commercial, Industrial, Process and Power, Engineering and Design.
1501 St. Catherine Street West, Montreal
NEW YORK • MEXICO CITY • PARIS • ZURICH

SWAN, WOOSTER ENGINEERING CO. LTD.
CONSULTING ENGINEERS
HARBOUR WORKS • INDUSTRIAL PLANTS • BRIDGES
HYDRO-ELECTRIC • STRUCTURAL DESIGN
Surveys • Reports • Design • Supervision
1334 W. Pender St. Vancouver 5, B.C. 520 S.W. Yamhill St., Portland 4, Oregon. 1685 Third Ave., Prince George, B.C.

B. B. TORCHINSKY & ASSOCIATES LTD.
PROFESSIONAL CONSULTING ENGINEERS
- Foundation Site Investigations
- Highway Design & Inspection
- Materials Testing Laboratory
- Asphalt Mix Designs
- Concrete Testing & Inspection

Drilling Rigs Located Throughout Western Canada
HEAD OFFICE
SASKATOON, SASKATCHEWAN
121 - 105th ST. EAST
REGINA EDMONTON WINNIPEG

UNDERWOOD, McLELLAN & ASSOCIATES LTD.
Consulting Professional Engineers
Calgary - Regina - Saskatoon - Winnipeg
MUNICIPAL • INDUSTRIAL • STRUCTURAL • MECHANICAL • ELECTRICAL • CIVIL • LAND SURVEY and COMMUNITY PLANNING
Partners in GIBB, UNDERWOOD & McLELLAN
Ottawa, Toronto and Vancouver

VANCE, NEEDLES, BERGENDOFF & SMITH, LTD.
CONSULTING ENGINEERS
EXPRESSWAYS • BRIDGES • AIRPORTS
Location and Cost Studies, Designs, Plans, Specifications
Supervision of Construction
35 SPRINGBANK AVE. WOODSTOCK, ONTARIO

W. L. WARDROP & ASSOCIATES (Management) Ltd.
ENGINEERING CONSULTANTS
Design and Inspectional Services for Municipal, Structural, Mechanical and Electrical Engineering Projects.
456 Notre Dame Avenue, Winnipeg 2, Manitoba. 47 N. Cumberland Street, Port Arthur, Ontario

THE WARNOCK HERSEY COMPANY LTD.
Consulting, Inspection, Expediting, Testing.
Mechanical, Electrical, Civil Inspections • Soil Mechanics and Site Investigations • Chemical and Physical Tests • X-Ray and Ultrasonic Examinations • Research • Industrial Appraisals and Surveys • Expediting.
Head Office: 128 Elmslie Street, Montreal 32, P.Q.
Branch offices: St. John's, Nfld., Sydney, Halifax, Trenton, N.S., Saint John, N.B., Montreal, Ottawa, Peterborough, Toronto, Hamilton, London, Windsor, Sault Ste. Marie, Winnipeg, Regina, Edmonton, Vancouver.

WIGGS, WALFORD, FROST & LINDSAY
Consulting Engineers
INDUSTRIAL SURVEYS, REPORTS AND APPRAISALS
CIVIL, ELECTRICAL AND MECHANICAL ENGINEERING
DESIGNS, SPECIFICATIONS AND SUPERVISION
TORONTO HUdson 1-6496 MONTREAL HUnter 1-7741 OTTAWA CEntral 6-5371

WOOD, McADAM & MAGOR
Consulting Engineers
STRUCTURAL - MECHANICAL - ELECTRICAL
DESIGNS, SPECIFICATIONS and SUPERVISION
4444 SHERBROOKE ST. WESTMOUNT, P.Q.
WE: 5-8587-8588

Denotes Membership of a Principal in the Association of Consulting Engineers of Canada

INDEX TO ADVERTISERS

JULY 1962

PUBLICATION OFFICES: The Engineering Institute of Canada, 2050 Mansfield Street, Montreal 2, Quebec, Canada.

Association of Consulting Engineers of Canada Incorporated

The following firms have principals who are members of this Association engaged as professional engineers in engineering work independent of salaried employment or sales promotion.

The revenue derived from the sale of advertising space assists the Institute in publishing THE ENGINEERING JOURNAL on a regular monthly basis. Listed above are the names of the Companies and individuals whose advertisements appear in this issue.

ADVERTISING OFFICES

QUEBEC: J. E. Danavan, Manager, Advertising Sales. Representative—Charles R. Amey, 2050 Mansfield Street, Montreal, Phone: VIctar 2-8121
ONTARIO: W. Marrison Day, 160 Eglinton Ave. E., Suite 103, Taranto, Phone: 485-0789
WESTERN CANADA: W. Gearge Turner, 501 - 191 Lombard Ave., Winnipeg, Man., WH 3-9123
UNITED KINGDOM: H. A. Mackenzie, 4A Blaomsbury Square, Landan, W.C.1, England. Phone: HOlborn 3779
EUROPE: Gustav Elm, 41 Avenue Mantaigne, Paris 8, France. Georg Linder, Wittelsbacher Allee 60, Frankfurt Am Main, West Germany.
NEW ENGLAND STATES: R. G. Melendy, 17 Maugus Avenue, Wellesley Hills 81, Mass. Phone: CEdar 5-6503
CHICAGO: W. Reynold Ratz, 549 W. Randolph St., Chicago 4, Ill. Phone: ST-2-8811
NEW YORK: Jahn H. Bayd, 17 East 45th Street, New York, Phone: MUrray Hill 7-0654
CALIFORNIA: Dunkle/Lehman Campany, 740 Sauth Western Ave., Los Angeles, Calif. Phone: DUnkirk 7-6149

THE ENGINEERING JOURNAL

VOLUME 45 NUMBER 8 AUGUST 1962

PUBLISHED MONTHLY BY THE ENGINEERING INSTITUTE OF CANADA, 2050 MANSFIELD ST., MONTREAL 2, QUE., CANADA • TEL. VI. 2-8121

Printed in Toronto

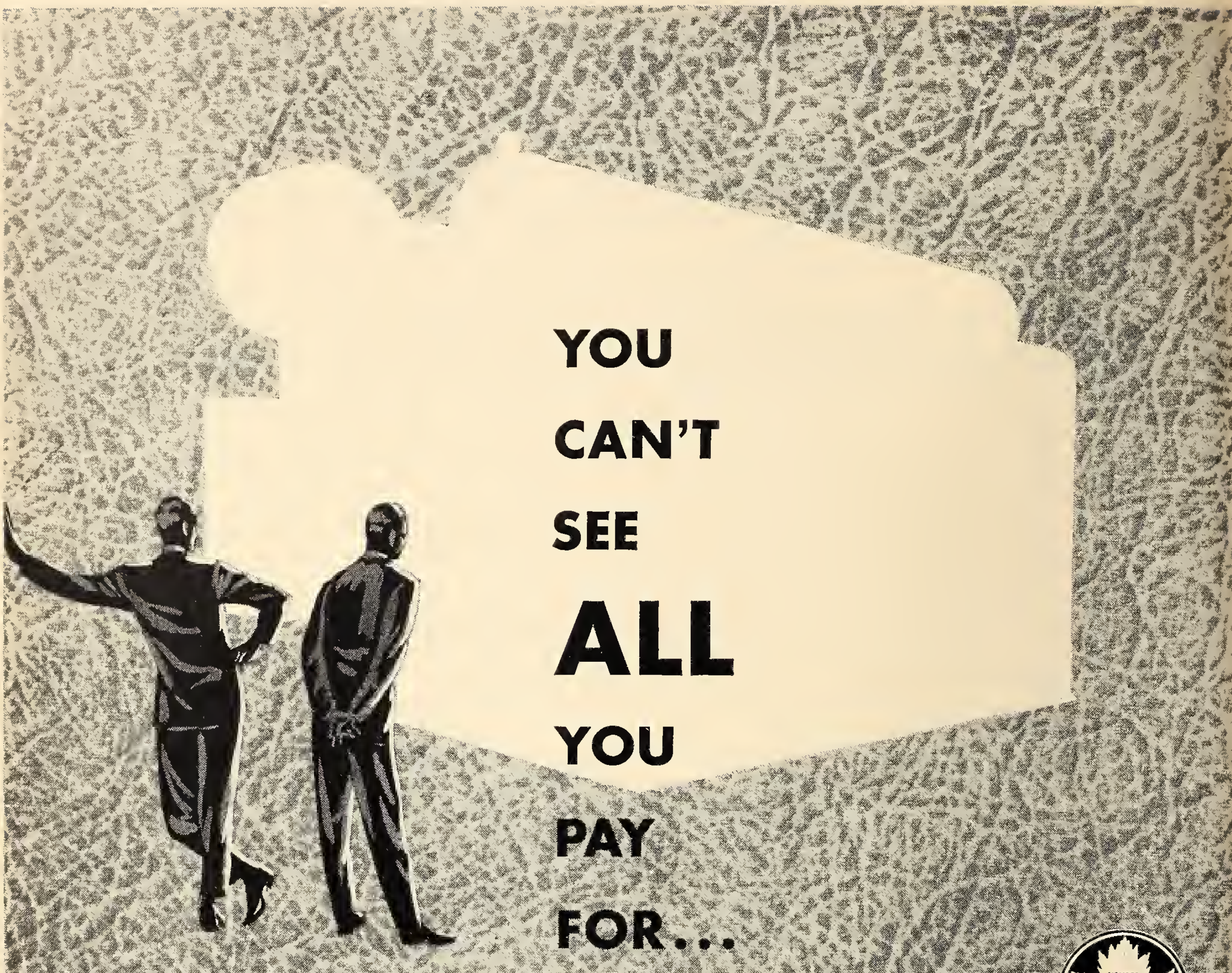
Price $6.00 a year in Canada, British Possessions, United States and Mexico. $7.50 a year in Foreign Countries. Current issues, 75 cents a copy, back issues from $1.00 per copy up. To members, affiliates and other bona fide engineers in Canada—no charge. Authorized as second class mail, by the Post Office Department, Ottawa, and for payment of postage in cash.

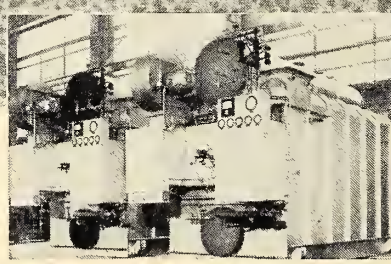
MEMBERSHIP

CCAB BNA

Indexed in
The Engineering Index
The Applied Science and Technology Index

CONTENTS





SPECIFY AND
BUY CANADIAN

When you buy a boiler, you buy heating surface. Other features look after convenience of operation, long term dependability . . . but heating surface is the major factor governing the *efficiency* of the boiler, and the ultimate cost of every pound of steam. That is why Inglis designers pack up to 10% more heating surface than other boilers into the 'PK' package. That is how they achieve thermal efficiency of up to 84%!

As for those "other features", Inglis 'PK' Steam Generators are designed with fully automatic or semi-automatic controls for use with liquid and gaseous fuels. Integrally mounted burner and control system are piped, wired and tested at the factory. Completely water-cooled walls and steel jacketed insulation keep heat losses to a minimum. Since the stack is mounted on the boiler no floor space is lost.

Inglis engineers welcome all enquiries for *efficient, low cost* steam generation.

Inglis

TYPE 'PK' STEAM GENERATORS

JOHN INGLIS CO. LIMITED

TORONTO MONTREAL WINNIPEG CALGARY VANCOUVER

Z.162

IN THIS ISSUE

John V. Hayward, Welding and Quality Control Engineer, Alberta Branch, Dominion Bridge Co. Ltd., in his paper entitled *"The Practical Use of Non-destructive Testing and Quality Control for Welded Steel Structures"*, examines the basic principles and the problems involved in setting up a weld testing and quality control program suitable for use in the construction of large steel weldments.

The need for quality control is explained, and to illustrate the current trends, examples are taken from various sections of the welding industry, and the more important Codes are discussed. The Plate Girder Highway Bridge, at Edmonton, an all-welded Rigid frame building at Regina, and the S.P.C. Head Office building at Regina are described and details of the non-destructive testing employed are given.

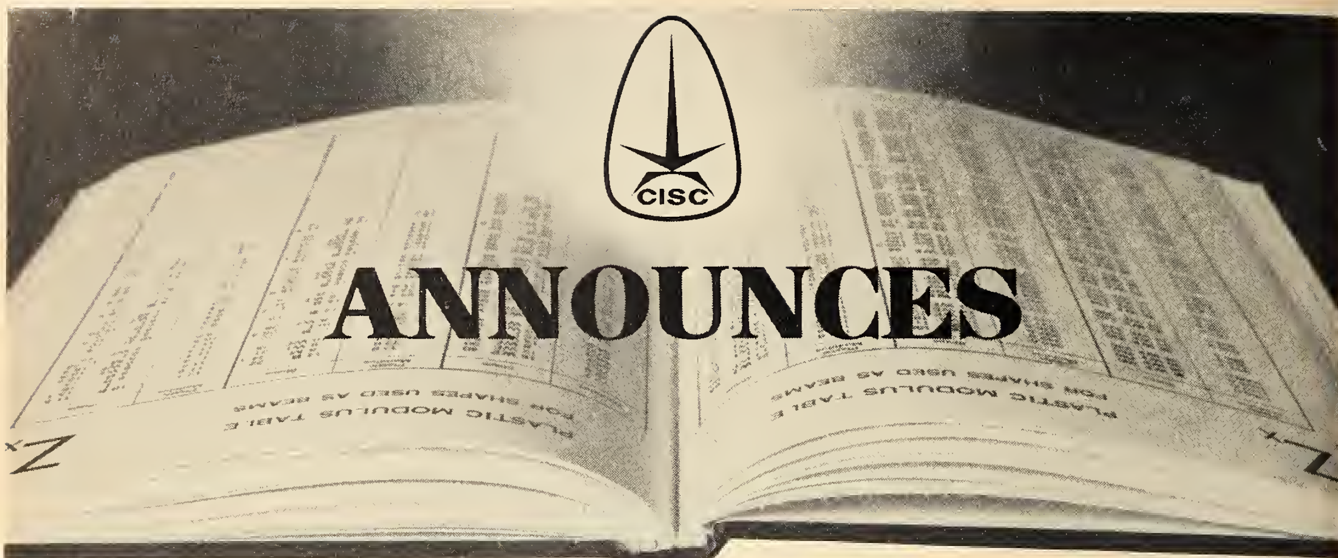
The established systems of non-destructive weld testing are described, together with an outline of their particular areas of usefulness, and their current state of acceptance. It is suggested in this paper that none of the N.D.T. systems now available can fully satisfy our present inspection requirements, and that the best results have been obtained when a number of the systems are used, each in the particular situations that are most favourable to their physical properties.

The dependence of the N.D.T. systems of today upon the skill of the technicians employed in their use is discussed in detail.

In their paper, *"Kemano Tunnel Operation and Maintenance"*, **J. B. Cooke**, Consulting Engineer, (Dams, Tunnels, Hydroelectric Projects), **J. W. Libby**, Assistant Chief Engineer & Vice President, G. E. Crippen & Associates Ltd., West Vancouver, and **J. T. Madill**, Assistant Manager, Power Division, Operations, Aluminum Company of Canada Limited give the operating and history of the Kemano Tunnel from its in-service date of July, 1954, until the present. Special tests before draining in 1961 are described. The maintenance and repair program carried out from June 19 to September 11, 1961, is outlined from the points of view of design, organization and execution. Finally, operating results are shown.

COVER ILLUSTRATION

The lead paper in this issue of the Engineering Journal inspects non-destructive testing and quality control for welded steel structures. Symbolizing this is the cover photograph of the half hooded welder and his work. (Photo courtesy Dominion Bridge Company, Ltd.)



Two new books

for Architect • Engineer • Specification Writer

Draughtsman • Student

BOOK ONE

STRUCTURAL STEEL MATERIAL SPECIFICATIONS . . . 118 PAGES . . . $2.00

Contains material specifications, notes on the selection of structural steels and the effects of alloying elements, metallurgical aspects of mill pricing and much more.

BOOK TWO

PROPERTIES OF SHAPES, PLATES, BARS AND TUBES . . . 160 PAGES . . . $3.00

A comprehensive study including elastic and plastic moduli tables, standard welded plate girders and columns, beam diagrams and formulae, weights of materials, etc.

AVAILABLE SOON

BOOK THREE: Structural Steel for Buildings (includes load tables and design aids).

IN PREPARATION

Welding of Structural Steel.
Design of Structural Steel for Highway Bridges.

BOOKS ARE CLOTH BOUND, SPECIALLY COMPILED BY THE ENGINEERING STAFF OF CISC TO PROVIDE THE MOST UP TO DATE INFORMATION ON THE LATEST CANADIAN PRACTICES IN FABRICATED STEEL CONSTRUCTION.

CANADIAN INSTITUTE OF STEEL CONSTRUCTION
388 Yonge St., Toronto 1, Ontario, Canada

Please send me:

Structural Steel Material Specifications.................( ) Copies at $2.00 each*
Properties of Shapes, Plates, Bars and Tubes...........( ) Copies at $3.00 each*

*Discount of 20% on ten or more copies of one book.

Name and Title..
Firm or Organization..
Street Address..
City..................................Zone................Province..............
Cheque or Money Order Enclosed ☐ Send Invoice ☐

MAIL THIS ORDER FORM TODAY

MR. MEMBER!

ABOUT THAT FEE INCREASE

MR. MEMBER, THE DECISION IS YOURS. Your Council has carefully investigated all our operations and has recommended the fees increase which is before you for action. Your Finance Committee has presented the facts. I wish to fill you in on the background which you may need to fully appreciate why we are asking you to vote in favour of the proposed by-law amendment.

In doing so, you are being asked to vote in favour of a modest fees increase, which your Council deems adequate. It is necessary if your Institute is to continue to serve you. **THE TOTAL AMOUNT OF THE FEE FOR A RESIDENT MEMBER, AS I HAVE INDICATED, WILL WORK OUT TO LESS THAN 10 CENTS PER DAY.**

Can you afford to do anything other than vote YES?

One of the most important issues currently before the EIC is the fees increase which Council adopted at its meeting of February 3, 1962, in the following terms:—

"THAT Council make it known to the membership that it is in favour of a general increase in fees, as shown in the following schedule, and

All Branch Residents		Branch Non-Residents and Non-Residents
$24.00	Fellows	$22.00
24.00	Members	22.00
14.00	Associate Members	12.00
3.00	Students	3.00
25.00	Affiliates	23.00

THAT its decision be made known to the membership in the Engineering Journal, and

THAT it advises the membership of its intention to present a notice of motion for the above increase in fees at the 1962 Annual General Meeting."

Details were made known to you in a graphic leaflet mailed to all members about May 1st. This leaflet indicated the following significant facts for the year ending December 31st, 1961:—

1. Our total income averaged $9.59 per member, made up of:—

Fees from members	$8.73
Revenue from investments	0.56
Miscellaneous	0.30
	$9.59

You might assume that you could easily check the revenues from membership fees by taking the number of members in the several categories at December 31st, 1961, and multiplying these by the corresponding fees. This is not so. Among the reasons this does not work out this way is that the number of members paying fees during a given year does not coincide with the numbers of members in the same categories at the end of the year. Some members are laggard in payment of fees. Moreover, there are, in some instances, losses associated with resignations. Finally, the average fees received from members resident in provinces where there are co-operative agreements in force are influenced by the terms of the specific agreements.

2. Our expenditures amounted to $12.76 per member, arising as follows:—

Administration (general services, communications, etc., for benefit of members)	$7.01
Direct services	4.26
Deficit from publications	0.43*
Building and rental	0.62
Confederation expenses	0.44
	$12.76

*The Engineering Journal is self-supporting. The deficit of $0.43 arises from publications other than the Engineering Journal.

3. You will see that the deficit amounted to an average of $3.17 per member.

The Chairman of the Finance Committee, Vice-President G. N. Martin, at the request of Council prepared a series of statements which I hope each of you have read. These statements are:—

a. "Basic Facts behind a Fee Increase". The Engineering Journal for March, p. 96.

b. "Your Professional Future". The Engineering Journal for April, p. 174.

c. "To Mr. EIC — Member and Associate Member". The Engineering Journal for May, p. 69.

d. "Where the Dollars Go". The Engineering Journal for June, p. 141.

e. "Need We Say More?". The Engineering Journal for July, p. 71.

Discussions with some of your Branch Executives and with members have indicated a need for clarification and emphasis on certain aspects. It is my hope this discussion will clear up these areas of uncertainty for you, because it is essential that every member clearly understands the issues at stake. Council's decision was taken after extremely careful deliberation. The presentations by the Chairman of the Finance Committee, to which attention has been drawn, were developed to give effect to the decision of Council. However, the ultimate responsibility rests with you as members. I hope you will carry out your responsibility in the appropriate manner when the ballot on by-law changes is mailed to you.

If you look at the statement of Revenues and Expenditures for the year ended December 31st, 1961, which appeared in the Annual Report published in The Engineering Journal for April, 1962, you will note, if revenues from, and expenditures on, publications are excluded, that:—

Revenues become	$208,237
Expenditures become	$267,900
The deficit is	$ 59,663

Some Branches have asked for details. You are entitled to them. One of these details relates to the item of Administration Expenses. These were, for the year ended December 31st, 1961:—

Staff salaries and benefits		$149,584
(You should know that the staff is overworked)		
Communications		11,356
Office supplies and services		26,169
Travel		9,898
General — Audit	1,075	
Interest	2,763	
Legal	80	
Other	216	4,134
Total		$201,141
Less: Recovery, re services rendered	1,362	
Publications overhead	51,706	53,068
Net administrative expenditure		$148,073

The difference between the $267,900 total expenditures shown and the $148,073 net administrative expenditure is due to direct service expenses, building and rental expenses, depreciation charges and extraordinary expenses.

The item of building and rental expenses breaks down as follows:—

The item of building and rental expenses breaks down as follows:—

Caretaker salaries	$ 2,940
Staff benefits	263
Property taxes	4,210
Fuel	1,079
Light and power	1,073
Insurance	507
House expense	1,306
Maintenance and repairs	1,293
Total EIC Headquarters	$12,671
Rental, EIC office in Toronto	900
TOTAL	$13,571

I should add here that an amount of $4,000 per year is paid on publications account for space occupied outside the Headquarters building, plus $400 for maintenance and repairs on this accommodation.

It would be possible to provide statistics for other items but these would be burdensome and possibly conducive to misunderstanding without extensive explanation.

I believe the foregoing quite clearly demonstrates the need for the fees increase.

I can assure you that all expenses are very carefully scrutinized before commitments are made. Our Finance Committee prepares a budget prior to the fiscal year. This is based on previous records and the application of the best judgement which can be brought to bear by the Finance Committee, the General Secretary and the Comptroller, working with forecasts of expenditures which various organizational units, such as the Student Policy Committee, deem appropriate to their activities. This budget, and the expenditures, are under continual examination.

I can assure you a great deal of time is devoted to ensuring that your money is wisely spent on the services which you enjoy.

At this point I suspect you may well ask: Why should I belong to EIC? Let me suggest to you why I believe you should belong to EIC.

When a young man graduates from an engineering college or faculty, he is equipped with the basic training needed by an engineer but very little else besides his health and the native ability with which he was endowed at birth. In other words, he lacks that important fund of specialized knowledge which can only be acquired by experience. This specialized fund of knowledge underlying the profession of engineering has been built up by our professional forebears. It is growing all the time through contributions made to it by members of the profession. Today, it is growing at an increasingly rapid rate due to the veritable explosion of technology.

When a young engineer graduates he must participate in those activities which will enable him to keep abreast of the growth in professional knowledge which he needs in order to effectively serve as an engineer, whether in the consulting field, in an industrial organization, in a utility, or in the public service. The reason is a simple one. As time goes on, the basic training he received at the college or faculty from which he graduated deteriorates. It has been said the value of this basic training deteriorates at such a rate the half-life is reached 10 years after graduation. There is now increasing evidence the half-life is reached some 5 years after graduation. Under these circumstances, how can the young engineer maintain his ability to serve as an effective professional? There is only one way. This is to be an active member of the learned society of his choice, in the engineering field.

Naturally, all of us who are concerned with the future of EIC believe this learned society should be EIC. Why should it be EIC?

The young engineer who belongs to EIC has the opportunity of exchanging viewpoints and know-how with fellow engineers at Branch meetings; at Annual General meetings; at Regional Technical Conferences; and at various other types of meetings sponsored by EIC. In addition to this ability to exchange experience and know-how, the engineer can participate in many valuable activities through working on committees. He can learn to express himself effectively, a most necessary ability if he is to achieve success. He can contribute to the fund of professional know-how by the presentation, and participation in discussion, of papers, thereby repaying his debt to his professional predecessors. In brief, the engineer has, through EIC, his opportunity of keeping abreast of the developing technology in which he is interested. Moreover, he has an opportunity of exchanging views with members in the other disciplines in the engineering field.

As a member of EIC, the engineer has access to the publications of sister societies, particularly in the Commonwealth and in the U.S.A., at member rates. He can participate in meetings of these sister societies at member rates as a member of EIC. EIC participates in joint sponsorship of many meetings such as the recent Hydraulics Conference in Montreal in 1961, the Heat Transfer Conference in Chicago in 1961 and the Railroad Conference in Toronto in 1962.

Do you know that there are 14 Technical Divisions covering specific fields of technical interest within the area of technology served by EIC through its Committee on Technical Operations? These are Bridge and Structural; Chemical; Civil; Communication, Electronics and Automation; Electrical; Engineering Education; Geotechnical; Hydro-Electric; Management; Mechanical; Mining; Research; Thermal; and Welding.

One of the basic objectives of EIC is building up Canadian engineering literature with specific attention to those fields in which Canada has won outstanding recognition. These specialized fields are hydro-electric power development, all aspects of paper-making, mining, some aspects of electrical equipment manufacture, power transmission, and the application of mercury-arc and other rectifiers.

Do you know that one of our members, H. R. Sills, Hon. MEIC, is recognized as one of the world's outstanding authorities in the design and fabrication of hydro-electric generators? Do you know that some of our consulting engineers in the paper-making field are retained by enterprises in such far-away areas as New Zealand and elsewhere? Do you know that Canada has an unusually high position in the power transmission field?

Do you know that in EIC a member has access to virtually all the disciplines involved in engineering technology? This is an aspect in which the Canadian engineering profession is fortunate. Only a few other countries have engineering organizations which embrace the whole field. These are India, Pakistan, Ceylon, Rhodesia, Federation of Malaya, New Zealand and Australia, all Commonwealth countries. Many countries are indeed jealous of our good fortune in this regard.

Do you realize that in the Federal Republic of Germany there are some 153 organizations in the engineering field? Achieving co-ordination amongst these requires a considerable effort and expenditure of manpower on the part of the co-ordination organization, VDI.

Do you realize that the Power Divisions of ASCE, ASME, AIEE and ISA in the U.S.A. have a closer basic affinity, one to another, than the parent societies? The whole history of engineering in the U.S.A. has shown that the profession has just about come full circle in that country. From the original military engineering, through civil engineering and thus to the major traditional branches of engineering, combination and merger are coming to the fore. Outstanding examples of this are the imminent merger of IRE and AIEE, the two major bodies in the electrical field. Other combinations are under consideration.

We are indeed fortunate in having an all-embracing voluntary, technical, professional, learned society in EIC. It is up to us to strengthen EIC and go on to greater achievement in service to our members. Do you realize that the proposed fee of $24.00 per annum for resident members works out at less than 10 cents per working day? Surely this is an insignificant amount to pay to keep abreast of our profession.

F. L. Lawton, President.

NOTE: This message has been made available in French to Councillors, Chairmen and Secretary-Treasurers of the Province of Quebec Branches. It will be made available to Members on request.

THE PRACTICAL USE OF NON-DESTRUCTIVE TESTING AND QUALITY CONTROL FOR WELDED STEEL STRUCTURES

J. V. Hayward

Chief Welding and Quality Control Engineer, Alberta Branch, Dominion Bridge Co. Ltd.

The paper examines the basic principles and the problems involved in setting up a weld testing and quality control program suitable for use in the construction of large steel weldments. Three recent projects are described with details of the non-destructive testing

IN THE PAST DECADE rapid strides have been made in bringing the art of fusion welding to that of a recognized science, nonetheless many people have distrust of welding due to the fact that the relatively small amount of weld metal deposited in a weld joint has a cast structure. Perhaps they do not recognize that today's welding, thanks to the metallurgist and welding engineers, is a miniature steel-making operation controlled so accurately that the quality of the deposited weld metal is able to match and generally exceed that of the parent metal it joins, whether it be a structural grade A7 or a high strength steel alloy. This fact holds true also for the more exotic materials of the space age such as titanium and zirconium. The modern atomic submarine and globe orbiting rockets could not be built economically by any other method. The quality levels required for these high performance craft are close to absolute perfection and this is of course reflected in the high level of quality control which is applied and the relatively high cost of the finished product. The design requirements for a welded bridge or multi-storey building, while of high level, cannot be compared with those required in the Atomic Power Reactor, and as the material and weld quality levels to be achieved have a significant affect on the cost of a large project, great care must be given to the choice of quality standards to be written into the specifications prepared by an architect or engineer.

Inspection and Quality Control

For many years inspection and quality control was viewed by many

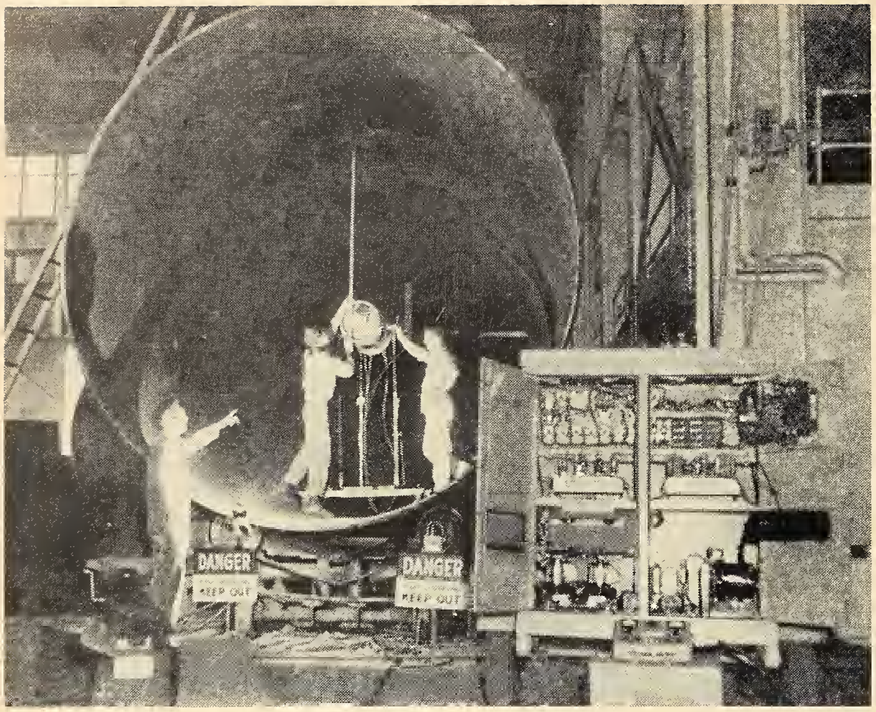


Fig. 1. 360 degree X-ray machine which exposes entire girth seam of 2½″ thick steel pressure vessel. Film placed around outside of vessel and operation completed with single exposure.

people in industry as a necessary evil and expense. It is, however, widely recognized that the mass of information obtained from this source has raised the general quality of welded products as a whole, raised production speeds and, most important, has greatly increased the confidence of all interested parties in welded fabrication. Experience has shown that fabrication costs are often highest where inspection and product quality control are low.

It should also be recognized that costs are unjustifiably raised when specifications are used which set quality requirements above the levels required for the particular service conditions. The pendulum effect has been observed in a number of industries where the inspection methods in use proved to be inadequate and significant failures have occurred. This has resulted in new specifications which are oriented toward the perfection end of the quality scale. Education and experience are the only solution to this problem of laxity followed by excess. Fortunately we can benefit from the successful experience gained with many thousands of weldments used in severe service conditions which have been fabricated under long established codes such as the A.S.M.E, C.S.A., A.P.I., and the A.W.S. Welded Highway Bridge Code, and the numerous government inspection specifications such as the California State Welded Highway Bridge Test Method No. CAL601C. Quality is a term which means many things to different people. Some people have used the term "the right quality", but this is patently a qualitative term. Sound engineering judgment, experience and detailed knowledge of the service requirements are necessary to reduce this to a quantitative value. In the idealized condition a standard has been chosen which is no better and no worse than is required for a particular service.

We have an urgent need in Canada for new National Standards specifically designed to meet the requirements of the designers of the space frame structures, bridges, and multi-storey buildings which will certainly be built in increasing numbers, using welded steel eonstruction, in the years to come. A committee of the Canadian Institute of Steel Construction is giving special study to the use of non-destructive testing systems, and establishing suitable weld defect tolerance standards for the different classes of service conditions; and it is anticipated that a recommendation will be handed to the C.S.A. for the early publication of the necessary revisions to their codes and specifications.

The Society for Non-destructive Testing, etc.

Of particular interest is the announcement of an imminent revision in the C.S.A. W-59 and the introduction of an allowance, of the full-strength welded butt joint equal to the full value of the connected metal whether loaded in compression, tension or shear. This advance was successfully introduced by the A.S.M.E. in 1958; and has already resulted in a large saving of steel in the pressure vessels built under that code. The reduetion in cost is the direct result of the new 100% weld joint efficiency allowance which is given for a vessel which has been subject to 100% x-ray inspection of the weld seams. The previous allowance was 85% maximum weld joint efficiency.

The Society for Non-destructive Testing and the Federal Government Department of Mines and Technical Surveys are also known to be making studies in the direction of suitable training programs and examinations for N.D.T. teehnieians.

The Federal Government Standard

Fig. 2. Welding field splices of 460′ long, 4 lane McKinnon Ravine Bridge, Edmonton. X-ray crew, behind welders, checked results on each row before allowing next stage of welding.

48-GP-4 for the Testing and Certification of Industrial Radiographic personnel is an excellent start and similar tests to cover the technicians using Ultrasonic and Magnetic Particle testing systems are urgently required. Federal and Provincial Governments, and C.S.A. testing and certification of welding operators employed in the pressure vessel, and structural steel industries is mandatory; and it is essential that the Welding Inspector who is empowered by the purchaser to accept or reject welded products, should himself be tested and certified as having attained a suitable level of skill and specialized knowledge.

International Institute of Welding

Canada is an active member of this body which was founded in 1948 in Belgium, to encourage the development of welding at the international level. By the organization of annual meetings which are attended by the welding technologists and scientists from the 28 countries who are taking part, it has promoted the free exchange of technical information and is performing outstanding work in producing welding and inspection standards. The I.I.W. has an important relationship with UNESCO, the Union of International Engineering Associations and The International Standards Organization. The rapid progress of the common market developments in Europe suggests that the activities of this body will continue to grow in importance.

The I.I.W. is composed of 15 technical commissions. Commission No. 5 (testing, measurement and control of welds) is presently under the Chairmanship of Prof. G. A. Homes of Belgium, with D. Kat of Holland serving as Secretary.

A major portion of the work of the Sub-commissions is devoted to Non-Destructive Testing, and each working group is made up of experts from the member countries. Advanced work has now been completed on Radiography, Ultrasonics, Magnetic Particles and Dye Penetrants and the results will soon be available for publication in the member countries. A reference collection of x-rays of welds up to 50 mm. (2 in.) thick and showing examples of five different degrees of weld discontinuities for each thickness, originally published for educational purposes, has now become a reference quality standard, and over 1,000 sets are in use. The 1961 I.I.W. Meeting in New York passed resolutions to extend this original reference set to include examples of aluminum welds. It was also agreed that the I.I.W. should publish a low cost printed edition entitled "Radiographs of Welds" which is now available in Canada.

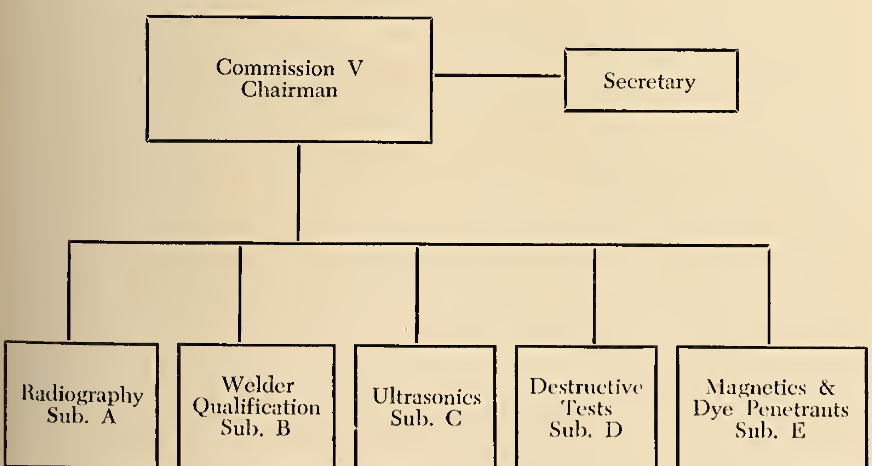
Welding Code Quality Standards based upon quantitative data directly related to knowledge of the effects of weld discontinuities in a specific service condition, are needed to replace the standards which have been established in an arbitrary manner. This quantitative information will become available in due course through the I.I.W.

Evaluation of the N.D.T.

The non-destructive testing inspection systems commonly used in the steel construction industry are:—

1. Visual
2. X-Ray & Gamma Ray
3. Magnetic particle
4. Matter in motion
5. Ultrasonic

Sub-Commissions of Commission V



Visual Inspection

This is the oldest, simplest and in some cases the most effective form of weld inspection available today. However, in order to be useful, this type of welding inspection must be continuous, it must commence before the actual welding process is started and should cover all the various stages involved through to the final completion of the joint. The visual inspection of a completed joint, while it may offer some clues to the quality of workmanship contained in the joint, is obviously limited to those defects which appear at the surface. The basic requirements in this case are good illumination, a magnifying glass and a man trained and experienced in the welding process, and the type of product that he is inspecting.

Under ideal welding conditions it is not difficult to produce very high quality welds on a continuous basis, and it is true to say that the majority of weld defects are found in the root pass of butt weld joints; and trouble in this area can usually be traced to improper fit up of the weld joint before the welding is started. Where the suitably trained inspector is on the spot, he can stop the work, and arrange for the materials to be re-fitted in the proper configuration intended by the designer. This type of quality control offers benefits like the proverbial stitch in time. The possible inclusion of serious defects in the root pass of butt weld joint is thus avoided, and usually results in greater care being taken in the fitting up of similar details by the people involved. The great improvement in weld quality today is not the result of greater skill on the part of the welding operator, the continuous effort towards improvement of weld consumables and welding equipment has made it possible to produce consistent high quality welded work with operators of very much reduced training and experience than was the case, say, twenty years ago. Here again, when the trained welding inspector is available, he can check the welding procedures being used, the welding machine settings and the welding technique of a group of welding operators on a particular job.

X-Ray and Gamma Ray Inspection Systems

In 1895, Doctor Rontgen discovered x-rays and produced radiographs of his hands, various pieces of metal and his shotgun which even, at this pioneer stage, revealed the presence of defects in the barrel of the weapon. The first recorded application of x-rays to a weld was in the following

year. Due to the primitive nature of the x-ray equipment at that time, there was no rush to make use of its potential in the welded products field. The next major step in weld inspection occurred in 1931 when the U.S. navy agreed to the approval of welded boilers subject to examination by radiographic methods. At the present time, radiography is the mandatory test for Class 1 vessels coming under the surveys of many important code authorities. Both x-rays and gamma rays are part of the electro magnetic spectrum but have shorter wave lengths than those of visible light. Their most important properties are as follows:—

1. They can penetrate matter whether it is opaque to light or not.
2. Travel in straight lines.
3. Are absorbed according to the density and thickness of the material through which they pass.
4. Fog photographic materials.
5. Make certain chemicals fluoresce and produce visible light.
6. They are dangerous to life.

The industrial type x-ray apparatus that is available at this time varies widely in range, design, weight and output. Weld radiography can be divided into two basic groups:—

1. The examination of welds in the plant;
2. The examination of welds on site, e.g., welded bridges and A.P.I. pipe lines and bulk oil storage tanks.

The equipment used for radiographic work in the plant is usually of the fixed or semi-mobile type, (photo No. 1) and has a capacity range in steel of from 1/16 in. up to 3 in. maximum thickness. For site work limitations are accepted in output, to enable the weight to be kept down to approximately 150 lb., which enables the machines to be used for weld examination on the light scaffolding that is erected to position the welding operators. Such units normally have maximum capacities in steel of some 1 in. to 2 in. in thickness, and they are usually powered by small gasoline engine A.C. generator sets.

The x-ray films are coated on both sides with a silver halide emulsion to obtain the maximum speed and contrast. For A.S.M.E., A.P.I. and C.S.A. Code radiography these high quality films are usually sandwiched in the film holder between cardboard that has been specially coated with calcium tungstate; or thin lead foil screens while making the exposure.

Fig. 3. Giant Plate Girder Jig in which a 120′ length of welded bridge girder is automatically welded by submerged arc process.

The salt screens can reduce the time of the exposure of a test weld by as much as 100 times, but there is some loss of sharpness. The lead screens will reduce the exposure time to a lesser degree, usually a half or one third, and are generally used on critical work as the lead emits both characteristic x-rays and photo electrons which serves to improve the quality of the image obtained, over that obtained from film exposed without screens. The contrast of films is generally higher, as the density of the film is increased, however, there is an obvious limitation due to the problem of viewing the darker films for interpretation. The following density ranges are recommended in the British Standard No. 2600 "General Recommendations for the Radiographic Examination of Fusion Welded joints in thickness of steel up to 2 in.

Film/Screen Combination	Optimum Density Range for Weld Image
Fine grain direct-type film, with lead screens	2.0–3.0 for X-rays; not less than 2.5 for Gamma rays
Ordinary direct-type film with lead screens	1.5–3.0
Screen-type with lead or Salt screens	1.5–2.3

Technique

To produce a radiograph of a weld the film must be on one side of the weld and the source producing the radiation on the other, the normal method is to direct the radiation perpendicular to the surface of the weld, but the beam may be deliberately angled to assist the identification of a lack of fusion on the side of a weld joint bevel, or double check for a suspected internal crack, or determine the position relative to the surface of an observed defect in a weld joining thick plates. On small dia. high pressure pipe the double wall technique is employed where the radiation is directed at a small angle from the center line of the butt weld at a film positioned close to the far side of the pipe, the projected image is recorded as an oval pattern and the film can be read for both front and rear sides of the joint. This method has also been used on butt welded box column sections formed from two rolled channel sections, welded toe to toe.

In establishing the best technique for the examination of a particular weld joint, it is necessary to calculate the optimum distance between the radiation source and the film, and this is directly influenced by the distance between the film to the farthest part of the weld to be examined, and the geometric size of the focal spot or radiant source. The maximum degree of unsharpness or penumbra is limited under the existing codes to .01 in.

Gamma Ray

It is not possible to make direct comparisons between x-rays which are emitted as a continuous spectrum, and Gamma rays where they are emitted as a line spectrum.

Gamma rays were discovered in 1896 by Antoine H. Becquerel while investigating the properties of uranium. The earliest successful application of gamma rays in industry was carried out by Henri Pilon and M. A. Laborde when they made a successful inspection of a defective ship turbine in France in 1925. The various isotopes now in use for industrial radiography produce smaller amounts of radiation output than x-ray machines and exposure times are normally considerably longer, however, they have the ability to penetrate materials of varying thickness and can produce excellent radiographs of assembled units containing different metals such as a revolver loaded with bullets, and oil and gas line control valves. The following list shows the artificial isotopes produced in atomic reactors that have been used successfully in industry.

Isotope	*Steel thickness in inches*	*Half life*
Thulium 170	1/2	127 days
Iridium 192	5/16–2½	74 days
Caesium 137	1–3	33 years
Cobalt 60	2–6	5.3 years

The half life is a convenient method that is used to describe the useful life of an isotope whose level of radiation output decays exponentially. An isotope may still be useful for radiog-

raphy after its half life has elapsed, depending upon its strength at the time it was produced. The gamma ray sources emit radiation continuously throughout their life, and the serious problems associated with their accidental loss, are such that very special precautions must be made whenever they are to be removed from their transport or camera containers. The isotopes due to their relative high power of penetration produce images on radiographic film that are of lower contrast than those obtained for a similar weld using x-ray equipment, and the inspector who is familiar with x-ray, but not isotope radiography, may well be led into underestimating the severity of an observed defect.

The use of radiography is not limited to metals, as wood, rubber, plastics and many other diverse materials have been successfully tested by this method. The isotope Ceasium 137 has been used to record serious cracks and voids in the concrete walls of a building, which were 12 in. thick, and recently techniques have been developed to locate and determine the condition of reinforcing steel in certain types of concrete structures.

Safety Procedures

Federal and Provincial regulations are now coming into effect that will do much to control the danger of radiation hazards in industry. The most important precautions in dealing with all radiation sources is to ensure that only suitably trained personnel are allowed to work with them. Care must be taken to keep all persons out of the main beam at all times and, in addition, the work area should be monitored with a suitable radiation detector for secondary or scattered radiation at each new location at which sources or x-ray equipment is to be used.

Radiographic Defect Tolerance Standards

Section UW-51 of the A.S.M.E. Unfired Pressure Vessel Code, Section 8 sets out the radiographic method and procedures and in readable form sets the level of defects that are acceptable in the case of 100% radiographic inspection of the shell seam welds of vessels built for service under their rules. These weld quality standards are as follows:—

"1. Any type of crack or zone of incomplete fusion or penetration:

2. Any elongated slag inclusion which has a length greater than

1/4 in. for T up to 3/4 in.

1/3 T for T from 3/4 in. to 2-1/4 in.

3/4 in. for T over 2-1/4 in.

where T is the thickness of the thinner plate being welded.

3. Any group of slag inclusions in line that have an aggregate length greater than T in a length of 12T, except when the distance between the successive imperfections exceeds 6L where L is the length of the longest imperfection in the group.

4. Porosity in the weld metal shall be judged acceptable or unacceptable by comparison with a standard set of radiographs or porosity charts;" however, it should be noted that many oil companies purchase their pressure vessels under this code but add numerous additional limitations based on their own service experience, e.g. the allowable porosity levels are often greatly reduced below those shown in the A.S.M.E. standards, particularly when the vessels are used in corrosive service environments.

"(M.) Sections of weld that are shown by radiography to have any of the above types of imperfections shall be judged unacceptable and shall be repaired as provided in Par. UW-38.

(N.) A complete set of radiographs for each job shall be retained by the manufacturer and kept on file for a period of at least five years."

Interpretation of Radiographs

This necessitates the identification of all the varied images that appear on a film and an understanding of their causes on this basis:

1. Knowledge of the weld preparation and the welding procedure used on the joint.

2. Position of the image.

3. Size of image.

4. Shape of image. The images appearing on the processed film may be the result of any of the three causes:

a) Internal defects in the weld metal.

b) Accidental marks upon the top and bottom surfaces of the weld spatter, grinding scratches, hammer marks, undercut.

c) Fortuitous images, formed by faults in exposure, processing and handling.

When reading the radiographs the film should not be held over a light bulb or against the clear sky but should be examined with great attention to detail in a darkened room using a specially designed x-ray illuminator from which all light other than that required to view the film has been masked; many authorities advise that a short time should be spent in allowing the eyes to adjust to the conditions in the viewing room before starting the examination of film.

Fig. 4. Two manual operators welding heavy flange butt welds of the leg to haunch field splice of the rigid frame Livestock Pavilion, Lethbridge.

Limitations of Radiographic Methods

It has long been recognized that these methods are unable to locate some planar type defects, such as laminations and cracks lying parallel to the weld surface. The A.S.M.E. Code requires the use of image quality indicators or penetrometers, for every exposure, these are small steel strips equal in thickness to 2% of the thickness of the weld being examined; therefore, the penetrometer for a weld 1 in. thick will have a thickness of 0.02 in. These must be placed upon the surface of the weld farthest from the x-ray film so that its image when recorded on the film will have travelled through the full thickness of the weld and appear clearly on the developed film. The penetrometers may be placed upon the weld on the film side of the joint, but in this case they are useless as a method of checking sensitivity, and can produce misleading results. The 2% sensitivity standard is a minimum value, and as the system cannot detect cracks and similar fine defects which are below the level of sensitivity being obtained in a given exposure, it is important that the technique used should be chosen to achieve the optimum sensitivity at all times, a skilled technician using fine grain film and good technique with modern x-ray equipment can often pick up image quality indicators 0.005 in. thick through a weld 1 in. in thickness. After a series of research studies by a commission sub-commission A working group into the relative merits of three different types of image quality indicators that are in use in the I.I.W. member countries, an official I.I.W. wire type image quality indicator has

Fig. 5. Manual welding of diaphragm plate in the 20 ton welded girder beam, Saskatchewan Power Building, Regina.

been selected and manufactured, for use as a standard penetrometer for welded products such as pressure vessels built under radiographic codes. and destined for shipment to any of the I.I.W. member countries. The ultimate objective is an international standard and specification for an image quality indicator for pressure vessels.

Despite the limitations of the method, the relatively high cost of equipment, and film, these radiographic systems have become the most important group of N.D.T. It has been estimated that over 100,000 miles of welded oil and gas transmission pipelines have been inspected by either x-ray or gamma-ray methods, and perhaps their biggest advantage lies in the fact that the radiographs form a permanent record, which can be checked by any number of engineers for many years after they are exposed. By keeping accurate records of the service life of the pipelines, pressure vessels or welded bridges, and relating this to the data available on the films, valuable information can be accumulated, on the significance of defeets in a particular service environment.

Magnetic Particle Inspection

This method of N.D.T. has been in use for more than 30 years, and is widely used in the aircraft and armament industries; although it has only received modest recognition in the construction industry. This is somewhat surprising as it is a relatively inexpensive method and has a sensitivity, range, and flexibility well suited to many of the weldments being produced in our structural steel plants. The equipment is produced in a wide range, for various specialized applications. The units that we employ in our plants for the inspection of welds, steel plate and rolled sections, forgings and eastings, are operated by two technicians, who provide a double check of the defect indications produced. The machines have a maximum output of 2,500 amp. A.C. and 2,000 amp. D.C. rectified current. For weld inspection on site we employ a 1,000 amp. A.C./H.W.D.C. machine which has been designed for one man operation, and weighs 160 lb.

The equipment is limited to the inspection of ferromagnetic materials; its operation is based upon the principle that a crack or non-metallic inclusion lying in a weld that has been magnetized will create local flux leakage field. Fine ferromagnetic particles are introduced across the test area, and offer lower resistance to the magnetic flux than air or liquid, the patterns that are formed by the coloured ferromagnetic powder which gathers over the defect, are easily interpreted by the trained technician. A.C. current is used for the detection of surfaee defects, and D.C. current for sub-surface defects. In common with the other test methods, various conditions which oecur in practice give rise to false indications, whieh will be recognized as sueh by the experienced operator, who has suitable experience with the produet under test, and understands the limitations of his equipment. A sub-Committee of the I.I.W. Commission V. is now investigating the sensitivity of this system, and the design of suitable standard test or calibration pieces.

Fig. 7. Magnetic Particle testing of heavy welds carried out at each stage of fabrication of the 20 ton beams. Portable 1,000 amp. DC Magnetic equipment weighs 160 pounds.

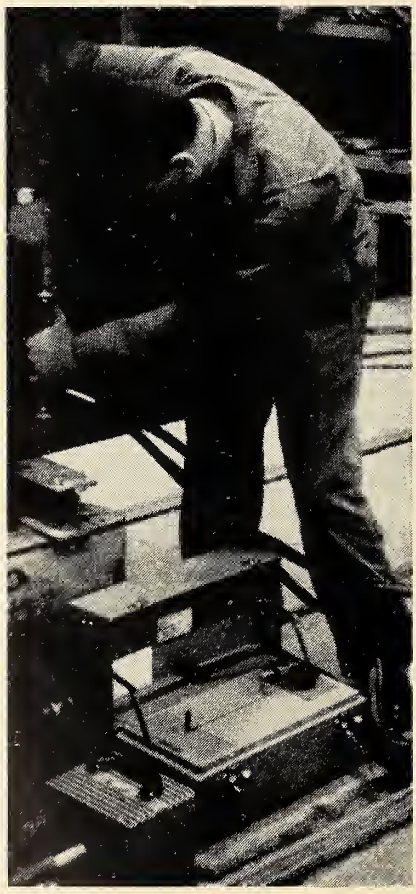


Fig. 6. Final check by Ultrasonic Testing of completed 20 ton beam.

The Matter in Motion Group

Essentially non-destructive testing methods involving the motion of matter, differ from those which are based on the transmission of energy, in that the defect must appear at the surfaee of the test material. Leak testing methods for containers of gases or liquids are as old as industry itself, some of the common tests involve the movement of water, air or helium through a defective weld seam. The helium leakage method is widely used in Europe, where large storage tanks are filled with the gas and the seams are scanned with a mass spectrometer, which ean detect helium at levels of one part/Mil. This is the most sensitive system in this group, as helium can pass through openings too small to permit the passage of water. The test is also used for heat exehanger, and pressure vessels, where it can be applied to both pressure and vacuum systems.

Dye penetrant systems are often used in the testing of non-ferrous weldments such as aluminum, copper, stainless steel tanks and piping for corrosion service. A colored dye is applied to the test area from small pressurized spray can, which has an extremely low viscosity which enables it to penetrate fine craeks and fissures in the surface of the specimen, the area is wiped clean, and a spray on white base developer is applied, which acting like blotting

paper shows the defects effectively. A later and more sensitive development of the dye penetrant, is one which fluoresces brilliantly when it is illuminated with an ultraviolet light source having a wave length of about 3,650 Angstrom units.

Ultrasonic Testing

This class of equipment was developed for industrial use during the early years of the Second World War, and has become accepted for certain classes of work which require the special qualities of ultra-sensitivity, (i.e.). It can easily pick up the grain boundaries in steel. The ultrasonic pulse echo equipment has the ability to inspect very thick steel plates and large turbine shafts where access is limited to one side of the plate or shaft. The nuclear power industry where quality standards approach perfection, has provided the opportunities and possibly the widest use of these methods, however, the system depends to an unusually high degree upon the knowledge and skill of the operator. Recent investigations by I.I.W. research teams in France, Holland and Belgium suggest that it is not possible at the present time to use the amplitude of the echo seen on the oscilloscope screen, as a criterion of weld defect size. If these results are confirmed it would not be possible to reject or accept a weld solely from a knowledge of echo amplitudes originating from defects. Nonetheless, the equipment has considerable potential, and has given good results when used for the detection of laminations in plates which are to be used for pressure vessels, and other weldments in severe operating service conditions. Semi-automatic and fully automatic equipment are now available that can carry out this task on a production basis.

The method is also used in Western Europe and the U.S.S.R., where spot x-ray is used on pressure vessels during fabrication — the entire length of weld seams are checked by ultrasonic equipment, and the x-rays are taken at the locations indicated by the ultrasonic inspection.

Many attempts have been made to substitute ultrasonic testing where x-ray inspection of welds is well established, a tentative specification entitled UW-53 was put before the A.S.M.E. pressure vessel code committee without success in 1958. In its present form it can be expected to fulfill those specialized needs for which the radiographic methods are uneconomic or impractical. It should be remembered, when considering these two methods, that x-ray and gamma rays on the one hand and ultrasonic waves on the other, are totally different in physical behaviour, and should not be expected to produce identical results.

Wherever ultrasonic testing equipment is being used, it is essential that the machine be calibrated at frequent intervals, to ensure that the results obtained are not being affected by malfunction of the mechanical or electrical circuits. The sub-commission C of the I.I.W. Commission 5, after five years of research work, have developed an ingenious equipment testing and calibration block which is now available, as an official I.I.W. Ultrasonic Reference Block.

Setting up a Quality Control Program

When a quality control program is to be set up for a large project, the biggest single problem to be faced is the human element, and in this area the vital importance of certain welds, often only a small fraction of the total amount of welding to be used in the structure, demands that sensible precautions, in the form of inspection and quality control, be applied throughout the fabrication and erection of a bridge or building. In making these decisions, it is important for the purchaser and his agents to understand that not all the fabricators who will bid on his project are equal in terms of their engineering capability and the quality of fabrication. It must be understood that less inspection and supervision by customers' inspectors will be necessary on a job in a first-class plant than on the same job if fabricated in a third-class plant.

The various types of non-destructive testing methods in use today have reached a very high stage of development, but unfortunately none of them has the capability alone to detect all the possible weld faults and define their size and location. The 100% inspection of all strength welds in a weldment, by any inspection test method, will not give absolute assurance that the quality levels set forth are being maintained. We must recognize that when these systems are used in the steel construction industry, the value of the results obtained depend, to a significant degree, on the skill and experience of the technician, and we must avoid the tendency to attribute abilities to these machines that they obviously do not possess.

To recognize the limitations of each inspection system is the first step in setting up an inspection program that will provide quality control; and reasonable assurance that the desired quality standards are being met. Often the best results are obtained when visual inspection by trained personnel is applied on a continuous basis, and a combination of the different non-destructive test methods are used on the important welds on either a 100% or a percentage basis.

The next important requirement is for the x-ray or magnetic particle testing to be applied on all of the initial work involving critical welds

Fig. 8. Of radical design the plan view of the Saskatchewan Power Corporation's new $7,000,000 office building resembles a great curving Y. There are no columns inside, and each floor provides a clear unimpeded 43′ x 270′.

in both shop and field, to detect and identify faulty work being produced by incompetent operation, faulty equipment, or procedural errors. Where these checks are carried out efficiently, the source of trouble can be quickly located and the necessary remedial action taken. By employing simple statistical quality control methods, it is often possible to bring the quality produced to the desired level quickly, and then reduce the x-ray inspection to a sample value of 5 or 10%. Whenever a deterioration in quality is observed, the x-ray is again increased to 100% until the optimum quality levels are attained. In this fashion, the major portion of the inspection effort can be concentrated upon the elimination of trouble spots.

Due recognition should also be given to some of the many factors which influence all forms of construction work today, such as current labour practises, seasonal employment, budgetary control methods, and the pressures of high volume and tight schedules during the short peak periods of the Canadian construction year.

To illustrate the current trends in weld quality control methods, three recent projects in Western Canada are described.

Project No. 1

All welded continuous plate girder highway bridge. Size: 460 ft. x 68 ft. Location: Edmonton. Completed: 1961. Consulting Engineers: E. M. Rensaa & Associates, Edmonton.

This bridge was designed to the A.W.S. and A.S.S.H.O. bridge codes for fabrication in A-36 steel. The project was completed successfully under the pressure of a tight delivery schedule.

Inspection and Quality Control

All tension flange butt welds in both shop and field splices, all field welded web joints; plus 10% of the remaining butt welds were inspected by x-ray techniques using the radiographic quality standards of the A.S.M.E. Section 8 "UW-51".

No special difficulties were experienced in meeting the pressure vessel code, x-ray quality requirements for both the shop welds and the twenty-four field welded girder splices. All web to flange fillet welds on the girders, together with the balance of the butt welds which were not radiographed, were inspected by two operators with a 2,500 A.C. D.C. Magnetic Particle Testing Machine (see photos 2 and 3).

Project No. 2

Livestock Exhibition Building (see Photo No. 4). All welded rigid frame. Span: 180 ft. Height at Centre: 36 ft. 6in. Length: 256 ft. Location: Lethbridge, Alta. Completed: 1961. Architects and Engineers: Lurie & Neufeld, Lethbridge.

This interesting structure was designed to C.S.A. S-16 specifications using steel conforming to the A-373 specification. The details for erection were specifically designed to avoid holes in each frame at the three field splice weld connections. The special deep gouging and welding techniques, developed at Lehigh University for the splicing of heavy rolled beams, was used to eliminate the need for cope holes in the web, at the leg to haunch field splices on each rigid frame.

Inspection and Quality Control

Continuous visual inspection was applied on all strength welds. All butt welds and web to flange fillet welds were tested 100% with a 2500 AC DC Magnetic Particle Testing Machine. Special precautions were necessary during erection, due to the high winds prevalent in this area and some wind gusts of 75 m.p.h. were recorded during the course of the erection. An ultrasonic unit was used to check the completed field splices for cracks and lack of fusion.

Project No. 3

Saskatchewan Power Commission Head Office Building. Welded multi-storey structure which provides a clear unimpeded space of 270 ft. x 43 ft. on each floor. Location: Regina. Completion date for steel contract: June, 1962. Architect: J. Pettick, Regina. Engineers: C. C. Parker, Whittaker & Co. Ltd., Edmonton.

This radical design makes use of a fusion welded frame and high tensile bolting of the wind bracing, and the floor beam connections, and is designed for the use of A-7 and A-36 steel under the C.S.A. S-16 specifications.

Inspection and Quality Control

Continuous visual inspection of shop and field welding. Magnetic Particle testing of all primary butt and fillet welds using a portable 1000 amp. machine. The structure incorporates two 20-ton welded girder beams, each supporting a line of columns above the first floor level, thus enabling motor vehicles to drive through the building. All materials in these critical members were inspected by ultrasonic equipment for laminations and segregations before fabrication. The ultrasonic equipment was also used as a final cross-check of the heavy butt and fillet welds used in the welded girder for possible cracks, and lack of fusion, before the girders were stress relieved (see photo 5 to 8 inclusive).

Summary

In conclusion, I would like to point out that both the science of welding and non-destructive testing applied to welds have unquestionably reached an advanced state of development. However, it is interesting to observe the significant amount of non-destructive testing that is used in Canadian industries today, and to compare this directly to the insignificant opportunities that are provided for the training of non-destructive testing technicians, up to a standard that would enable them to meet our present day requirements. When the suitably trained non-destructive testing technician is available, it must be appreciated that his responsibility is to locate, identify and establish the severity of discontinuities in welds. It is an engineer's responsibility to use this information to determine whether the significance of the reported defects is sufficient to warrant repair to the affected area or to render the product unsuitable for the intended service.

The welding industry in general has now adopted all the non-destructive testing systems and would appreciate the general application of these methods to the testing of welding operators, in lieu of the present mechanical semi-destructive tests which are both expensive and time-consuming. These semi-destructive, welding operator qualification tests, sometimes described as torture tests, are often carried out as a mandatory requirement for the manufacture of welded products which will themselves be accepted for service on results obtained by non-destructive testing examination.

The architects and engineers would undoubtedly benefit from new national codes which would enable them to prepare specifications for their major projects, e.g. bridges, buildings, etc., which will include simple, unambiguous descriptions of quality standards for materials and welds, closely related to the actual requirements of the intended service conditions.

The welding fabricators must continue to meet the challenge of competitive structural materials, and also the steel products from other countries. However they require specifications that recognize the significant improvement in quality of present day welded structures, and the assurance which can be obtained from the efficient use of quality control and non-destructive testing. EIC

KEMANO TUNNEL OPERATION AND MAINTENANCE

J. B. Cooke,
Consulting Engineer, San Francisco, Cal.

J. W. Libby,
Asst. Chief Engineer and Vice-President,
G. E. Crippen & Associates Ltd.

J. T. Madill, M.E.I.C.
Assistant Manager, Power Division,
Aluminum Company of Canada, Limited.

THE KEMANO TUNNEL is part of the Nechako-Kemano-Kitimat Development of the Aluminum Company of Canada, Limited, located on the west coast of British Columbia, 400 miles northwest of Vancouver. The engineering of the development and of the Kemano tunnel is well presented in the References.[1]

The Kemano tunnel carries water ten miles from the Nechako Reservoir at West Tahtsa to the 2600 ft. level above the Kemano Power Station. The tunnel has a grade of 2.5 ft. in 1,000 ft. It was designed to have a nominal 25 ft. horse-shoe shape, but rock variations and difficulties caused some modifications to this. As completed in 1954, 28% was concrete lined, 39% lined with unreinforced gunite, and 33% unlined. The invert is paved throughout. From West Tahtsa to the Horetzky adit the weighted average area is 485 sq. ft., and from Horetzky to the 2600 level, 545 sq. ft.

The intake at West Tahtsa comprises trash racks, stop log position, fixed wheel gate, and a 4 ft. x 4 ft. air shaft. The crown of the tunnel at the intake is 49 ft. below the reservoir surface. The Horetszky adit intersects the tunnel at the mid-point, and on the tunnel grade. It is closed off by a concrete plug having a 10 ft. x 10 ft. opening with a steel door, through this plug. This adit is reached by six miles of construction class mountain road with an average grade of 8%, up a narrow valley.

At the 2600 level at Kemano the concrete-lined surge shaft rises at a steep angle from the tunnel to the surface. Its area is 609 sq. ft., slightly more than that of the tunnel, and its lip is 253 ft. above the tunnel crown at this point. The two 11 ft. dia. steel-lined penstocks start at the end of the tunnel, 150 ft. beyond the surge shaft.

Summary and Conclusions

During the first seven years of operation the 10-mile tunnel performed adequately. However, head losses exceeded design head losses and measurements and investigations were carried out.

The Kemano tunnel was drained in June, 1961, under controlled conditions after thorough analysis indicated a major rockfall. A time was selected when the supply of aluminum to customers would not be affected, with adequate advance notice to residents of Kitimat, and at the most favorable season of the year. The advance planning and preparation was correct and adequate.

The size of the major rockfall, and

the amount of work to be done on the smaller falls and seams was greater than could have been anticipated, but an orderly expansion of the program already under way made possible the completing of all the repair work in twelve weeks at a cost of $2,100,000. A hydraulic conduit to meet all necessary conditions was constructed through the major cavern using a construction sequence which was executed without accident. Minor falls were repaired by concrete lining or bolting and gunite, and seams by dental work utilizing bolting and reinforced gunite.

There was no damage to the concrete-lined sections, to the invert, or to the major length of the unlined or gunite section. All the falls were due to the action of water on erodible seams. The falls have been permanently repaired and all seams sealed by gunite dental work. It is considered that there is no engineering probability of a future significant rockfall. Tests made since the repair indicate that the tunnel will carry slightly more than the original calculated maximum flow.

The cost of the 1961 repair and maintenance work was unexpected and disappointing. However, that cost was only a small fraction of the cost of an original eomplete lining. The Kemano tunnel experience makes it possible that future unlined tunnels can be more reliable and economical, since repair and maintenance can probably be anticipated and avoided.

Operations Prior to Draining in 1961

During the seven-year period from mid-1954 to mid-1961 the tunnel performed adequately and in no way restricted operations or caused significant abnormal maintenance. The valves and their seals, the turbine needles, nozzles and buckets, indicated only the most minor wear or abrasion from sand or gravel. Yet the rocktrap was in a stabilized condition full of sand, and a substantial amount of fine material did pass through the turbines. Certainly, no maintenance of the items listed arose from this cause in this 2500 ft. head station having 150,000 h.p. four jet vertical impulse turbines.[2]

From the filling of the tunnel in mid-1954, until mid-1956, both the load and the flow were very low, about 1,000 c.f.s. for a tunnel of 4,800 c.f.s. maximum rated capacity. With additional load coming on in 1956, checks at the Kemano 2600 level indicated a mueh lower than normal pressure. This gave rise to considerable testing and study, and tunnel loss tests were conducted periodically from that time.

Investigations Prior to Draining

Investigations ineluded periodic head loss measurements, the scheduling of "flushing flows" (described later), drilling piezometer holes, tunnel salt velocity tests, and water-hammer test. The purposes of the investigations were to measure the changes in head loss, to reduce head loss, and to locate and determine the nature of the hydraulic obstruction.

Head Loss Measurements

Tunnel flow, whieh is power station discharge, is determined from needle openings or the kilowatt-hour meters. Both were calibrated during efficiency tests using the Gibson method for measuring water. Pressure readings at the intake (West Tahtsa Intake), the only adit (Horetzky Adit), and the downstream portal (Kemano 2600 level), made it possible to aceurately determine the losses in each half of the tunnel. The pressures at Horetzky adit and Kemano 2600 level were determined by 60 p.s.i. and 150 p.s.i. gauges, calibrated by Ashcroft Dead Weight Tester. The accuracy is determined by the accuracy of interpolating the position of the gauge indicator needle.

Table I presents the head loss measurements from the first measurement, 1.8 years after initial operation, to the draining seven years later, and also measurements in a 4.5 month period after the outage and repair. the loss coefficient is

$$C \times 10^{-5} = \frac{H_f}{Q^2}$$

where H_f is the head loss in feet and Q is the flow in c.f.s. Prior to mid-1956 the flow was very small.

The readings in Table I without a letter A, B, or C are readings at the normal flow at the time of the reading. The readings with a number followed by A, B, or C are readings for a "flushing test". Only sufficient flow readings are included in the table to illustrate what occurred. A "flushing test" consists of a reading at high flow with a normal flow before and after, the B. reading being the high flow reading.

The first "flushing test", consisting of readings 19-A, 19-B, and 19-C, was made when additional capacity was installed, to see the effect of in-

TABLE I.

Kemano Tunnel Loss Coefficients
Loss Coefficients x 10^{-5}

Test Number	*Test Date*	*Flow C.F.S.*	*Tahtsa Horetzky*	*Horetzky 2600*	*Total*
2	28/5/56	1270	1.44	0.99	2.42
8	11/6/56	1327	1.48	1.09	2.53
9	18/6/56	1554	1.35	1.06	2.41
10	25/6/56	1659	1.15	0.98	2.11
11	27/6/56	1716	1.18	0.97	2.15
19-A	30/7/56	1707	1.43	0.93	2.36
19-B	30/7/56	2352	0.80	0.74	1.54
19-C	30/7/56	1709	0.82	0.74	1.56
27-A	28/9/56	1710	0.87	0.77	1.64
27-B	28/9/56	2444	0.81	0.50	1.31
34-A	21/3/57	2220	0.76	0.57	1.33
34-B	21/3/57	3767	0.47	0.46	0.93
34-C	21/3/57	2176	0.46	0.48	0.94
36	11/9/57	2108	0.51	0.48	0.99
38-A	4/7/58	1974	0.55	0.57	1.12
38-B	4/7/58	4041	0.48	0.47	0.94
39-B	21/8/58	4258	0.47	0.42	0.89
40-A	2/10/59	1968	0.52	2.25	2.27
40-B	2/10/59	3651	0.49	0.74	1.23
41-A	31/8/60	2375	0.48	1.62	2.10
41-B	31/8/60	3315	0.43	1.17	1.60
42-B	2/9/60	3244	0.47	1.10	1.57
45-B	29/9/60	3245	0.46	1.15	1.61
46-A	24/11/60	2402	0.50	1.45	1.95
46-B	24/11/60	3010	0.49	1.37	1.86
46-C	24/11/60	2383	0.47	1.31	1.78
47-B	20/1/61	2940	0.45	1.42	1.87
48-B	13/6/61	2981	0.48	1.43	1.91
	Design	4200	0.43	0.32	0.75
49-A	1/12/61	2266	0.34	0.40	0.74
49-B	1/12/61	4332	0.34	0.34	0.68
49-C	1/12/61	2259	0.34	0.40	0.74
50-A	19/1/62	2268	0.35	0.34	0.69
50-B	19/1/62	4178	0.34	0.33	0.67
50-C	19/1/62	2258	0.34	0.34	0.68
51-A	26/1/62	2220	0.34	0.33	0.67
51-B	26/1/62	4203	0.34	0.32	0.66
51-C	26/1/62	2222	0.34	0.33	0.67

creased flow. Since the head losses were reduced by "flushing tests", these were run intermittently at subsequent times. It was finally concluded that the higher velocity of the flushing tests was levelling the rockfalls, and that there were rockfalls in both halves of the tunnel, and at least one major rockfall in the Horetzky-Kemano 2600 half of the tunnel. The head loss discussion that follows for each half of the tunnel is written with the knowledge of the falls as seen during the inspection.

The high flows (B) which were in excess of power demand were obtained by opening the turbine needles with jet deflectors in the fully deflect position, the turbines being stationary. Thus, 150,000 h.p. was deflected on to the walls of the wheel pit. This is a procedure not to be undertaken lightly and was done only when necessary.

Tahtsa-Horetzky Losses

Test No. 2 (28/5/56), 1.8 years after initial operations, the loss was 3.4 (1.44/0.42) times the design loss. It is equivalent to the loss of a tunnel of about one-half the cross-section area, and could only be caused by one or more obstructions. Since the velocity was low, about 2 f.p.s., rockfalls of small rocks could provide the obstructions. Apparently the rockfalls occurred in the first 1.8 years.

On the Flushing Run No. 19-B (30/7/56), just two months later than Run No. 2, the coefficient which had remained constant at about 1.40 was reduced to 0.80. The velocity was temporarily increased from 2.9 to 3.9 f.p.s. Apparently the rockfalls did not get worse during the two-month period and the higher velocity levelled them out somewhat, resulting in lower head losses.

On Flushing Run No. 34-B (21/3/57), eight months after Run No. 19-B, the coefficient, which had remained constant at about 0.80, was reduced to 0.47. The velocity was temporarily increased from 3.6 to 6.3 f.p.s. Apparently the rockfalls did not get worse during the eight-month period, and the much higher velocity (6.3 f.p.s.) levelled the rockfalls further than the previous flushing velocity of 3.9 f.p.s.

On Run No. 46-C (24/11/60) the loss coefficient remained essentially at 0.47, with only slight increase between several intermediate flushing flows. Apparently there was little, if any, increase in the rockfalls during the 3.6 year period. Confirming this, there was little evidence of fresh rockfall on the June 19, 1961 inspection, except for one of the several falls which was actively and slowly enlarging due to numerous soluble seams.

It appears that the rockfalls occurred in the first two years and remained essentially stabilized for the following five years.

Horetzky-Kemano 2600 Losses

On Run No. 2 (28/5/56), about 1.8 years after initial operation, the loss coefficient was 0.99, three times the 0.31 design value. Apparently the rockfall had commenced in the first 1.8 years. In the next several months the loss increased and varied in the 1.00 to 1.30 range.

Between Flushing Run No. 19-B (30/7/56) and Flushing Run No. 40-B (2/10/59), a period of 3.2 years, five flushing runs were made, and the loss coefficient was held to a value of 0.74 with variations between 0.48 and 0.81 and a high of 2.25, just prior to Run No. 40-B. Apparently the rocks were generally small enough to be rearranged by the flushing flow and rocks were falling all during this 3.2 year period.

After Flushing Run No. 40-B (2/10/59) it was not possible to develop high flushing flows due to the gradient being down at Kemano 2600 level. The coefficient varied in the range of 1.10 to 1.37. Apparently the rocks were somewhat rearranged by changing flows, but not the larger ones, and the increasing loss would indicate that rock was continuing to fall. Some of the very large rocks under the cavern were water-worn.

The hydraulic evidence seems to indicate that the major rockfall began in the first 1.8 years and was active during the following five years.

Piezometer Drill Holes

In 1956, in an attempt to determine if head loss was concentrated in certain sections of the tunnel, five diamond drill holes were drilled from the surface to contact the tunnel. Two of these were a few hundred feet each side of the Horetzky adit, and one was one-half mile from West Tahtsa. These were about 600 ft. deep. A fourth hole was drilled three miles from Tahtsa, 850 ft. deep, and a sixth 4 miles from Tahtsa, 1000 ft. deep.

Water level during tests was measured by a contact head on a graduated line, using a bridge circuit as a detector at the surface. The data from these holes did not show any significant difference from what was learned from the Horetzky adit readings.

The surface topography did not make it feasible to drill other holes between Horetzky and the 2600 level.

Salt Velocity Tests

By late 1960, the tunnel operating data, and the regular head loss tests indicated that the maximum flow obtainable through the tunnel was about 3000 c.f.s., due to the high loss in the lower half of the tunnel. The obvious question was: "What is causing this excessive loss of head?" This led to a series of special tests in late 1960 and early 1961.

The question of whether the high loss was distributed throughout a length of the tunnel or concentrated in a short distance was very important, as this would reveal something of the nature of the cause of the tunnel loss.

A determination of water transit time from West Tahtsa to Horetzky to the 2600 level would indicate something about the loss distribution, because obviously a shorter than theoretical transit time indicates a reduced tunnel section over a considerable length, whereas a more or less normal transit time indicates a concentrated loss.

Salt velocity tests were conducted by releasing 500 lbs. of calcium chloride under water at the intake just below the trash racks, and at the level of the tunnel crown. The passage of this was detected at the air shaft at West Tahtsa, at Horetzky, and at the 2600 level, using sensitive, rather high-speed graphic milliammeters in circuits having electrodes in the tunnel water, or in a continuous sampling of the tunnel water. The whole procedure was very carefully timed. Typical diagrams obtained at Horetzky and the 2600 level are shown in Fig. 1. Three tests were conducted in late 1960 and early 1961, and the results are summarized in Table II.

As expected from the fact that the loss coefficient for the upper half of the tunnel was within 10% of the design value, the transit time for this half averaged about 86 minutes against a theoretical time of 88 minutes, while a calculation based on the uniform distribution of the actual measured loss gave 84 minutes.

In the case of the lower half of the tunnel, with a loss coefficient of 4½ times the design value, the actual transit time as measured was 91 minutes against a theoretical time of 101 minutes, and a calculated interval based on uniformly distributed losses of just 55 minutes. It became evident that the loss was not distributed along the tunnel but must be caused by some rather concentrated obstruction.

Water Hammer Test

Independent data and additional information would be derived from transient pressure wave behaviour in the tunnel, so a test was conducted

in which all of the load with the exception of the auxiliaries, comprising just 8%, was instantly dropped, while high-speed pressure charts with carefully timed coordination were obtained on recorders connected at Horetzky and at the 2600 level. A re-plot on the same graph of the first part of each of these is shown in Fig. 2. Prior to load rejection the flow was 2495 c.f.s. and after 195 c.f.s If the tunnel were behaving as a single, uniform conduit with a simple surge shaft at the Kemano end, obviously the pressure waves would be sinusoidal, in phase, with the Horetzky record having exactly one-half the amplitude of the 2600 level record. Some thought about Fig. 2 will reveal the system behaved as though it were two sections of uniform conduit connected through an orifice located between Horetzky and the 2600 level with, of course, the surge shaft at the 2600 level, the whole system having rather heavy damping. An approximate analysis made with several simplifying assumptions, on the basis of the momentum of the various parts of this water column, indicated the orifice might be in the range 4,000 to 8,000 ft. downstream from the Horetzky adit. This test served to confirm the conclusion that there was probably a fairly concentrated physical obstruction between Horetzky and the 2600 level.

Decision to Unwater, Repair and Maintain Tunnel

These three separate sources of information, therefore, led to the conclusion that there was a fairly concentrated physical obstruction between Horetzky and the 2600 level; that this obstruction was quite large; and that it was located on the order of one mile from Horetzky. The obvious cause of such an obstruction is a large rockfall. Planning was based on this conclusion. For planning it was also assumed that there might be some smaller rockfalls and some seams requiring repair and maintenance.

Kitimat Works, with a rated capacity of 192,000 tons of aluminum ingot per year, having a market value of over $7 million per month, and employing about 2,000 persons (some 1,400 of whom would be laid off), and the community of Kitimat with a population of 8,500 are completely dependent upon power from Kemano. It is unthinkable to shut down such an operation if customers are to be disappointed and the town disturbed, if there is any means of avoiding such a drastic step. If such a step must be taken, it should be taken at the most advantageous time, if such exists, for all eoncerned. The tunnel loss coefficient actually decreased until late 1958, and it was not until early 1961 that test data made it seem certain that a rockfall in the tunnel was causing the trouble. At this time aluminum reduction capaeity was eonsiderably greater than the world demand, so customers would not be affected. Obviously, access to the Horetzky adit, obtaining materials for concrete, and necessary repair work could be performed much better during the summer season. Also, this season works the least hardship and in general affects employees and the community least. (Eligible employees reeeived holiday pay, S.U.B., and Unemployment Insurance). The earliest a shutdown could be scheduled would be the coming summer. Therefore, in February, 1961, tunnel draining was scheduled for June 19, 1961. At this time the estimate was the shut-down would last from five to eight weeks.

Months in advance of the shutdown, consultants and a contractor were secured, probable repair designs were developed, and materials required were ordered. Well in advance of the actual date, construction equipment and bulk materials were hauled to Horetzky.

TABLE II.
Salt Velocity Tests

Test Number	*1*	*2*	*3*
Date	3/12/60	7/12/60	6/1/61
Flow C.F.S.	2410	2402	2430
Tahtsa-Horetzky			
Measured loss coefficient x 10^{-5}	0.47	0.47	0.47
Measured head loss, feet	27.3	27.1	27.8
Assuming uniform loss, calculated interval, Min.	84.4	84.6	83.7
Assuming actual area, calculated interval, Min.	88.4	89.0	87.9
Actual measured interval, Min	89.3	86.3	82.5
Measured interval, % of calculated	101.0	97.0	93.9
Horetzky—2600 level			
Measured loss coefficient x 10^{-5}	1.45	1.45	1.45
Measured head loss, feet	84.3	83.7	86.8
Assuming uniform loss, calculated interval, Min.	55.9	55.1	54.5
Assuming actual area, calculated interval, Min.	101.3	101.6	100.4
Actual measured interval, Min	90.5	92.1	91.1
Measured interval, % of calculated	89.3	90.6	90.7

Design Considerations—1961 Repair and Maintenance

Three principal types of design had to be considered for the repair and improvement of the tunnel; re-establishment of the conduit through the major roekfall area, stabilization and support of rock at areas of minor falls; and the sealing and support of any seams which had deteriorated during the seven years of operation. Each type had to have a permanent form of repair sinee any subsequent unwatering could not be contemplated.

Major Cavern

As only a fall of major proportions could serve to explain the character of the head loss being experienced, any method of reconstruction through the fall area would have to take into consideration:

(a) Safe and rapid construction.

(b) Capacity for maximum tunnel flow of at least 4800 c.f.s.

(c) External hydraulic pressures resulting from the lowered hydraulic gradient during power operations.

(d) Internal hydraulic pressures created by load rejection at the power plant.

(e) Heavy impact loads due to blocks of rock falling from the roof of the cavern.

(f) External statie loads which would result from caving within the eavern after completion of the conduit.

Preliminary Design—Major Cavern

A proposed design and construetion method was evolved which consisted of:

(a) Heavy 12 in. wide flange steel sets with a semi-eircular rib and vertical posts. Surmounting the set and supported by an extension of the posts, a horizontal member could be bolted to provide a "portal" on which timbering or crown bars could be supported;

(b) Sets were to be placed at a 2 ft. 6 in. spaeing;

(c) Timber cribbing and blocking was to be carried forward as the sets were placed and cribbing was to be built at least 6 ft. above the crown of the set to provide protection from falling rock within the cavern;

(d) Sets and cribbing would be eoncreted to provide a conduit through the cavern.

Five sets fully cribbed and blocked were computed to be able to sustain an impact load of a 4 ton rock falling about 30 ft.

Upon eompletion of the temporary support system for the eomplete

length of the cavern, the steel sets were to be welded at the connections and anchored to the tunnel floor to act as stress steel for internal pressures. Concrete was then to be pumped into the cribbing so that a total depth of at least 6 ft. above the tunnel crown was obtained to form the permanent conduit.

Preparations Prior to Draining

From consideration of the kind of rockfall necessary to produce the orifice observed, it was obvious that this same fall would act as a rock-fill dam when the tunnel was drained. It was anticipated that the crest of this dam would be under the cavern, greater than 25 ft. high, and would create a pool at least 25 feet in depth. This pool would taper in depth to end 10,000 feet upstream. Therefore, pumping would be the first operation after the opening of the Horetzky adit door. Four propane-fueled pumps on two steel barges having a total capacity of 4000 g.p.m. were provided, along with 8500 ft. of 12 in. dia. steel pipe in 40 ft. lengths with couplings.

Construction equipment was selected in advance and was on hand at the adit when the tunnel was unwatered. A criteria was that it could be brought through the 10 ft. x 10 ft. and 12 ft. long opening in the adit plug. Eight 5 cu. yd. dumpter units (later increased to 12) were selected for hauling muck out and concrete in. Mucking machines were a 1½ yd. Trackscavator, and a 1½ yd. overhead loader. A jumbo was prefabricated in panel trusses to go through the adit opening and be quickly assembled. A D-7 bulldozer tractor, 3 ton flat deck trucks, and cranes could be taken through. Three two-man truck-mounted boom "Giraffes" were brought in by removing the booms. Other standard construction equipment such as 600 c.f.m. air compressors, 15 to 30 kw. lighting plants, air receivers, farm tractors, D-4 tractors, pick-up trucks, guniting equipment, and a pneumatic concrete placer posed no problem. All diesel units for underground were equipped with scrubbers, and all gasoline units converted to propane fuel.

A portable batching unit with bins and scales, loaded by a truck crane with a clam was set up outside the adit, along with a portable ½ yd. paving mixer to supply concrete. For aggregate, a crusher was set up alongside to produce 3,000 cu. yds. of 1½ in. aggregate, using tunnel muck from the original construction. 2,000 cu. yds. of sand were hauled from the Kemano valley, and 10,000 bags of cement, with a further 14,000 bags at the Kemano dock.

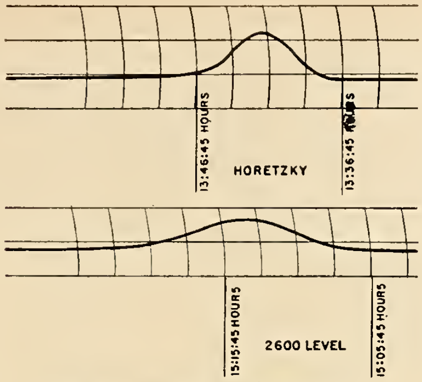


Fig. 1. Salt Velocity Test No. 2.

As indicated in the design, 50 tunnel sets of 12 in. WF 40 lb/ft. steel were on hand with material for 50 more in the fabricator's shop, (these were not required). Ten 8 in. WF 17 lb/ft. steel sets were on hand. (10 more were ordered and a number of 6 in. and 8 in. steel sets from the original construction were also used).

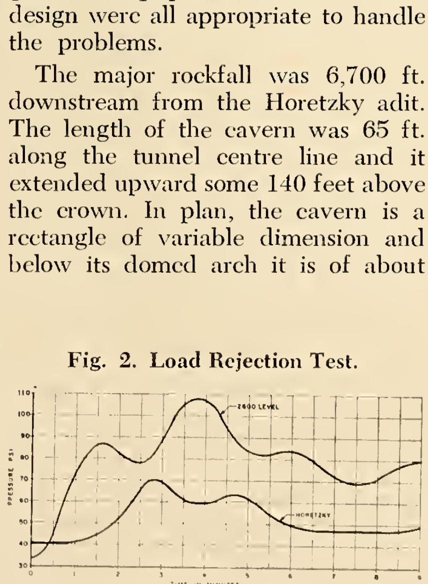
Prefabricated panels for concrete forms and several thousand board feet of timber were available, all of this before tunnel draining.

Inspection

The tunnel was drained at the controlled rate of pressure decrease of 5 ft. of head per hour on June 18 and 19, with the intake gate fully closed at 1:52 a.m. and all Kitimat load off at 4:01 a.m. June 19. Inspection parties entered the tunnel at both ends and at the adit within two or three hours of the planned time. Conditions as found in the tunnel were very close to those anticipated except "quantitatively", i.e. there were many more cubic yards of rockfall from the main fall than were anticipated, and more minor falls had occurred. The planned equipment, materials and design were all appropriate to handle the problems.

The major rockfall was 6,700 ft. downstream from the Horetzky adit. The length of the cavern was 65 ft. along the tunnel centre line and it extended upward some 140 feet above the crown. In plan, the cavern is a rectangle of variable dimension and below its domed arch it is of about

Fig. 2. Load Rejection Test.



70 x 100 ft. dimension. The main jointing and seams are in planes essentially perpendicular to the tunnel axis. From this cavern 25,000 loose cubic yards were transported and deposited in a 2600 ft. length of tunnel downstream before large rocks under the cavern accumulated to make a secure major obstruction. The rocks under the cavern sharply peaked some 20 ft. above the tunnel crown and were of very large size, 8 to 12 ft. dimension. They were well interlocked and water worn. At each end of the cavern the hydraulic opening was irregular and averaged about a 5 ft. depth below the crown. Just downstream from the cavern the "jet" had excavated the rocks to a 15 ft. depth from the crown for about 60 feet, and further downstream for several hundred feet large (4 to 10 ft. dimension) rocks projected above a bed of rocks, with the top of bed about 2 ft. above the spring line (10 ft. from crown). For the remaining distance the surface of the muck sloped very moderately downward from 15 ft. deep to 10 ft. deep where it dropped off in a short 2:1 apron of well-graded sand and gravel. Excavation of the downstream 900 ft. of muck showed a dense well-graded 'streambed' material with only one or two rocks greater than ½ cu. yd. In the next 700 ft. there were eight rocks of 2 to 6 ton (1 to 3 cu. yd.) size, and in the upstream 1,000 ft. there were many large rocks embedded in smaller material. The 'armor surface' of the material was mainly of about 12 to 18 in. size with smaller rocks and occasional gravel visible in the surface voids. The velocity over the muck was 10 f.p.s. normally, and as high as 15 f.p.s. during "flushing flows".

The geological report on this rockfall was:

"This occurred in fresh, hard, medium crystalline pink to grey colour quartz diorite. The dominant structure in the rock is a fault that crosses the tunnel at approximately a right angle and dips vertically to 80 degrees upstream and downstream. The fault contains from ⅛ in. to 2 in. of mylonite and gouge and in some places the wall rock is chloritized and softened for distances up to several feet on either side of the fault. Two sets of closely spaced fractures, probably related to primary jointing occur, one on either side of the fault. The set of fractures downstream of the fault is essentially parallel to the fault and its members are 4 to 7 ft. apart for a distance of 30 ft. from the fault and strike into it toward the north, and its members are spaced from 7 to 10 ft. apart. All of the fractures in each set are interconnected by cross

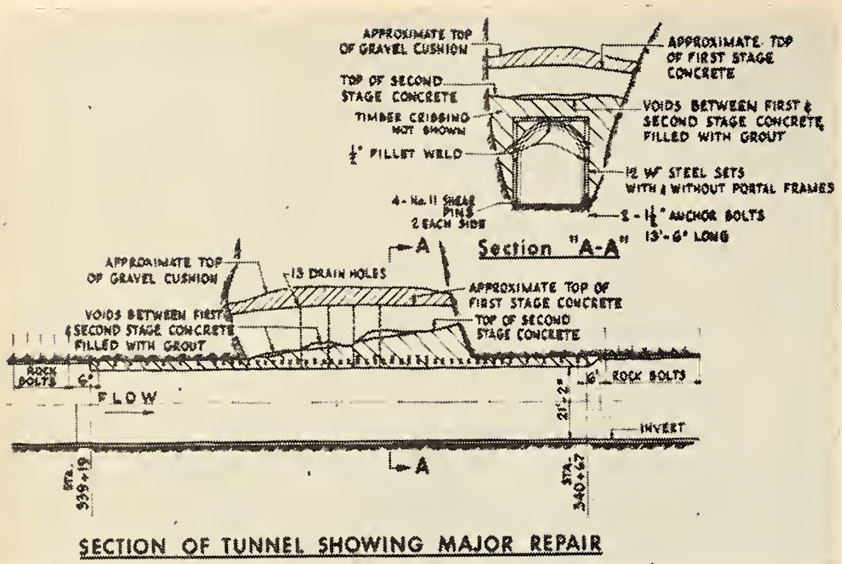


Fig. 3. Section of Tunnel Showing Major Repair.

fractures that are most abundant near the fault."

Upstream from Horetzky there were a number of minor falls and six dams of debris with one exception all containing a small amount of material. The exception, a dam formed by two falls close together, contained about 2,500 cubic yards.

Again the geologists reported: "Mylonite and/or gouge filled fault zones were associated with each of these collapses. These zones range in width from ¼ in. to 9 in. and are generally locally host to calcite and/or quartz lenses and veinlets. Examination of well over one hundred faults in the tunnel revealed that where a fault is filled solely with gouge or solely with mylonite, erosion seldom exceeds an inch in depth, but where the two fillings occur together or where one or both occurs with calcite, the depth of the erosion of the filling extends from inches to tens of feet. Apparently the dissolving of the calcite loosens the packing of the filling and permits increased water circulation and continuing erosion. Similarly, the differential erosion of the mylonite and the gouge tends to make each material unstable and the filling is removed more easily than if it consisted of just one of the materials."

This was from a report by Dr. Victor Dolmage and Dr. D. D. Campbell, consulting geologists.

Some 200 seams (1 in. to 2 ft. wide) that were erodible were seen. The seams were mainly concentrated in a 6,000 ft. length of tunnel starting three-quarters of a mile above Horetzky; and in which length four of the above 'other falls' occurred. They had 'worked' to depths varying from inches to feet to the order of 10 ft. Most of the seams had stabilized due to pinching off or reaching tightly wedged rock. Those that were active could not be imagined to create a major rockfall in the future, but possibly minor ones.

There were no failures of concrete sections. All original gunite was unreinforced, thin, and applied on a freshly washed rock surface. The gunite downstream from Horetzky was ¾ in. thick and well applied. The gunite upstream from Horetzky was of irregular thickness and in some areas thin.

A two-mile continuous length of tunnel near the downstream end was fully unlined, with no concrete or gunite sections. In this section there were no rockfalls and only several isolated narrow seams that were active. There were not more than about 10 spalled pieces of rock 4 to 12 in. thickness and 2 to 4 ft. in slab dimensions. There were also occasional smaller rocks. These spalls from the blast-damaged surface are normal; fewer than in most tunnels; and of no consequence. The unlined tunnel, where there are no erodible or soluble seams, was of very satisfactory quality and in good condition.

Following the preliminary inspection geologists mapped the entire length of the tunnel, noting and marking all points of deterioration or of potential damage. This information served as the basis for the specifying of the work by the consulting engineer, and the organizing by the contractor. It is significant that the inspection revealed that most of the rock lining of the major cavern, and with very minor exceptions, that of all of the other rockfalls, was covered with the same very thin layer of brown slime that covered the tunnel, indicating almost no fresh or active falls.

Actual Design—Major Cavern

Repair operations commenced in accordance with the proposed plan. As temperature and moisture conditions changed within the main cavern, rock began to fall with increasing frequency. It became evident that the proposed sequence of repair could not be used.

First, a timber bulkhead was constructed across the tunnel just upstream of the cavern. The space behind the bulkhead was filled with tunnel muck and a 4 x 6 ft. timber ventilation duct pulled over the muck pile to connect the tunnel at each end of the cavern. Crushed rock backfill was then pneumatically placed around and over the ventilation duct to a level just above the original tunnel crown. Attempts were made to shape the surface of the fill to the intrados of a flat arch and the perimeter walls of the cavern were washed. Approximately 1000 cu. yd. of high slump concrete was then deposited in a continuous operation over the entire cavern area just above the tunnel so as to form a protective arch which varied in thickness from 12 to 6 ft. with an irregular shape roughly 35 ft. wide by 65 ft. long. A 3 ft. layer of ⅜ in to ¾ in. crushed rock was then blown on to the top of the concrete to form a cushion to assist in absorbing impact of falling rock. All of these difficult operations had to be accomplished from the protection of the tunnel upstream of the cavern with virtually no exposure of personnel.

Excavation and placing of sets then proceeded under the protection of the concrete arch. Sets were blocked to the bottom of the concrete to serve as support in the event the arch was not structurally complete or did not thrust against sound abutments. At the north side near the midpoint of the cavern it was found that the protective arch concrete had flowed around talus material which, when removed resulted in a rather large opening between the tunnel and the cavern above. This opening was sealed by again bulkheading, backfilling with gravel, and placing concrete. Excavation was then completed through the cavern area without further difficulty. Forms for the water conduit were erected and final concreting was accomplished in two stages so as to fully encase all sets and lagging and fill the space up to the protective arch. After setting shrinkage of the concrete had occurred, grout was pumped into the remaining voids between the second

stage concrete and the protective arch. The resulting structure was a virtually monolithic water conduit passing through the bottom of the cavern. The completed water passage was of horse-shoe shape 18 ft. 9 in. wide and 21 ft. 2 in. high, as shown in Fig. 3.

No attempt was made to stabilize the cavern to prevent it from working. It is interesting to report that the impact of rocks upon the protective arch could be clearly heard very frequently during the excavation and second stage concreting operations.

The concrete thickness of the roof of the conduit was dictated primarily by construction requirements. Because of the great thickness, 14 ft., and the proximity of the rock at the side walls, the structure was analyzed essentially as a wedge rather than an arch. It was estimated that falling rock will eventually fill the cavern completely. Calculation showed that this load, reduced by arching or "silo-effect", could be safely supported. Distance to ground surface at the location of the cavern is approximately 1200 ft.

The pressure increase at the location of the cavern due to load rejection at the power plant was computed to be about 140 ft. of water. The steel sets were, among other considerations, sized and spaced to provide full tension reinforcing of the conduit for this head change. Connections were welded for full stress transfer. Special anchorages for each set post, consisting of four, 1½ in. high-strength bolts embedded a minimum of 9 ft. 6 in. into rock, completed the internal pressure resisting elements. To slowly equalize pressures between tunnel and cavern, thirteen 1⅜ in. holes were drilled in the crown.

The safety of the conduit against damage from very large rocks falling from great heights was the most difficult problem. Conditions within the cavern suggested the possibility of a 20 ton block falling 100 ft. before the accumulation of a debris cushion. Very little literature was readily obtainable regarding the ability of concrete to safely absorb large amounts of energy from very heavy impact loads. Studies indicated that fine gravel placed over the concrete would provide a simple an inexpensive means of assuring the safe absorption and distribution of impact energy. A minimum gravel cushion of 4½ ft. was indicated, but because of uncertainties in assumptions, a 10 ft. depth was planned.

Fractures in the tunnel at each end of the cavern and the probability that the cavern would continue to work required an extension of protective measures upstream and downstream of the actual fall. Steel sets and concrete lining were continued for 48 ft. upstream and 32 ft. downstream of the cavern. Beyond the concrete lining, a pattern of rock bolts, reinforcing, and wire mesh, all covered with gunite, was extended an additional 32 ft. upstream and 34 ft. downstream over the roof of the tunnel.

Minor Falls

Several minor falls were found within the tunnel where up to several hundred cubic yards of rock debris had fallen from the roof or sides of the tunnel. Most of these falls occurred where two or more fracture zones were close together or where fine mylonite filled seams swarmed across the tunnel. The resulting void was generally normal to the tunnel, above the spring line and as much as 20 ft. wide and extended into the roof from 15 to 50 ft.

Conventional concrete tunnel lining, placed by a pneumatic machine, was used to isolate the cavern from the conduit. Minimum concrete thickness of the arch was dictated for the most part by the available forms and the tunnel shape at the particular location. The thickness generally averaged about 24 in. As much concrete as possible was forced into the fall void, giving a thickness of at least 6 ft. over the crown. Special design to resist internal pressure was necessary at only one of the minor falls.

Light steel sets were used where necessary to assure safe working conditions or where concrete reinforcing appeared desirable. Generally the side walls were placed first to the spring line after which the complete arch was placed in one continuous operation.

The finished cross section of the repaired zones had nearly the same waterway area as sections lined during original construction. Reinforced gunite transitions were constructed at both ends of each new concrete repair. The longest concrete section protecting a minor fall zone was 70 ft.

Downstream of the major cavern, at a location where it was impractical to move tunnel forms, a minor fall was repaired by use of steel sets which were blocked to rock and cov-

Fig. 4. Repair of Seams.

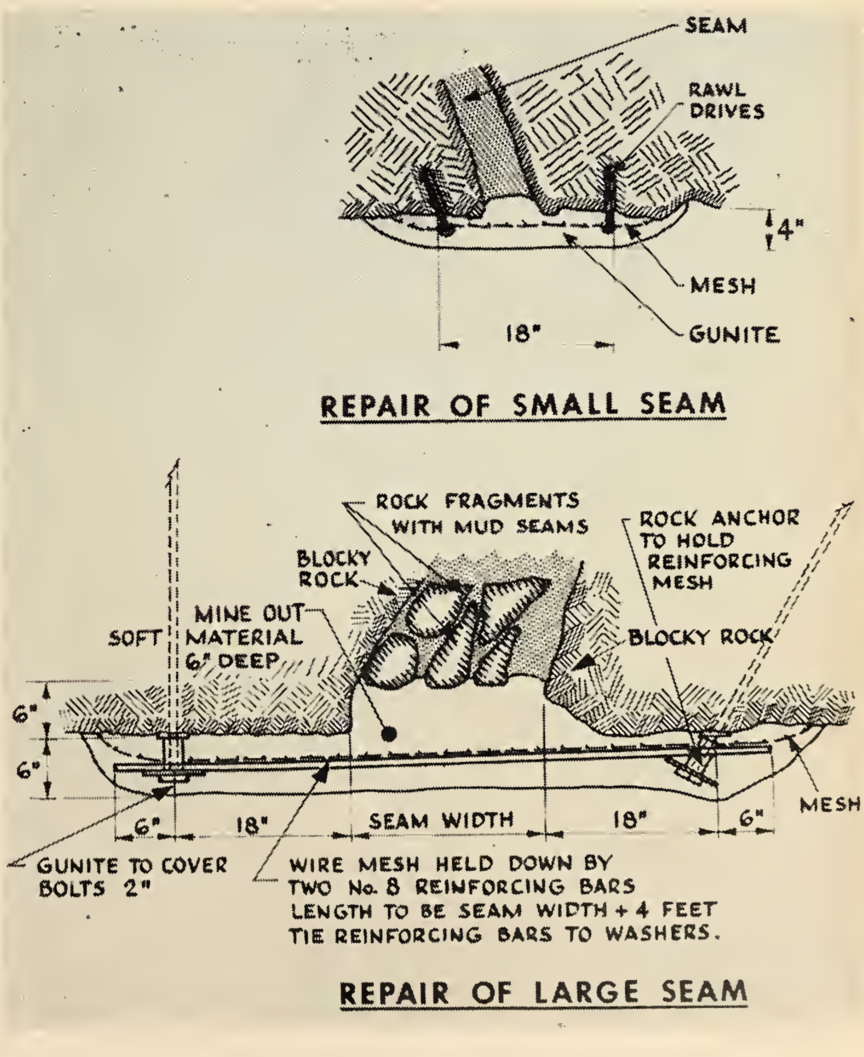


TABLE III.
Materials Hauled to Horetzky

Propane	7500 gals. Including Tanks	60 tons
Gasoline	5000 gals.	20 "
Diesel Fuel	50,000 gals.	200 "
Cement	39,000 bags	1,700 "
Timber	300,000 board feet	380 "
Steel	All types	240 "
Sand	4,100 cubic yards	4,400 "
Miscellaneous	Supplies	450 "
Equipment	117 pieces	410 "
	Total	7,860 tons

ered with wire mesh and gunite. Gunite thickness was built up to about 4 in. along the tunnel to fully protect and stabilize the sets and to seal the rock from further water action. Six sets spaced at 6 ft. were used.

Seams

The large number of exposed seams required a simple repetitive method of repair. The seams were generally filled with mylonite (microbrecciated rock), and varied in width from a fraction of an inch to several feet. In areas of the tunnel where a thin spray of gunite had been applied as a temporary measure during excavation, the gunite had spalled from portions of the seam, exposing the seam to the action of the water. It was in the gunite seetions that most of the seam repair was necessary. It was deeided that all seams which showed evidence of dissolution should be permanently sealed and protected from further water attack. Where a seam was partially exposed by spalling it was traeed by chipping the unspalled gunite.

Experience in other tunnels had demonstrated the simplicity, effectiveness and permanency of properly applied gunite adequately reinforced and anchored. Experience in the Kemano tunnel also showed the large amount of protection furnished by unreinforced gunite. A standard design for repair of seams of various widths was developed which permitted easy designation within the tunnel and facilitated the supply of common items of material. Two standard types of repair are shown in Fig. 4. Three sizes of rock anchors were used; a short 6 in. x ⅝ in. bolt anchored by driving lead washers into a predrilled hole; a 3 ft. long, ¾ in. diameter mild steel bolt with a standard expansion type rock anchor; and standard 6 ft. or 8 ft. high-strength, ¾ in. diameter rock bolts.

A 2 x 2 by #10 wire mesh was used for reinforcing where gunite thickness did not exceed four inches. Where thicker gunite was required, a 4 x 4 by #8 mesh was designated so that the gunite would fully contact rock before building up on the mesh.

The fundamental requirement for successful gunite repair on rock is proper surface preparation to assure bond. Great care was taken that gunite was deposited on clean, sound surfaces. Seam debris was removed to a depth neeessary for structural thickness or to fresh, hard material. Reinforcing and anchorages were proportioned to the seam width and surrounding rock conditions so as to prevent cracking of the gunite and resist any hydrostatic loads which might develop due to pressure changes within the tunnel. It was essential also that water be prevented from circulating along mylonite seams and reactivating seam erosion.

The types of seam repair employed at Kemano proved very practical and appear to be the only method which would have permitted completion of so many repairs in the short time available.

Construction—1961 Repair and Maintenance

The propane engine-driven pumping equipment on the barges was very successful and the water was pumped down at the rockfall from 23 ft. deep to 2 ft. in eight days.

Equipment listed under 'Preparations' was all of the correct type. To cope with the increased quantities, certain units were duplicated or increased in number, mainly the dumpters, concrete placing, guniting and drilling units. Also, all service vehicles and units were increased to be able to work effectively both upstream and downstream from Horetzky.

To reduce the mucking time, an operation was set up to haul material from the downstream end of the pile at the major cavern out through the 2600 level at Kemano. Here access was by means of a rollout seetion in one 11 ft. diameter penstock. This meant a timber roadway 8 ft. wide could be installed. Thus, small equipment had to be used. The solution was four trains eomposed of rubber-tired farm tractors drawing three or four rubber-tired farm wagons carrying 3 cu. yd. steel boxes fabricated for this purpose. The wagons were loaded at the face with a 1 cu. yd. front end loader, and dumped at the 2600 level by picking up the wagon with a boom truck. The haul was 3½ miles eaeh way. Three-shift operation of this unorthodox arrangement cleared 1600 lineal ft. of tunnel of 16,300 cu. yd. of material in seven weeks. This effectively eut three weeks off the time of the shut-down.

Ventilation problems could not definitely be predicted in advance. When indications of contaminated air were detected, six exhaust fans were installed at West Tahtsa, and a bank of 12 oil heaters at the bottom of the surge shaft at the 2600 level. The heaters were later replaeed by a wooden diaphragm with eight fans in it exhausting up the surge shaft. Two sets of doors in the penstoek opened for hauling muck prevented the short circuiting of the fans. All fresh air entered at Horetzky and aecess here was not interfered with. Kitimat Works uses a very large number of fans of all types so that immediate availability and considerable flexibility was possible in dealing with this ventilation problem.

All forces were housed at Kemano and travelled back and forth over the Horetzky road by bus. Obviously, the manpower required had to be greatly increased in order to work three shifts and in many places simultaneously. The total force was built up to 140 by the end of June, 250 by mid-July, 350 by mid-August, and remained at this figure to the first week in September.

Table III lists the major items of materials and supplies hauled to Horetzky and used. Table IV lists the quantities of bulk materials handled at Horetzky.

Upstream from Horetzky concrete was placed in 12 locations, with steel

TABLE IV.
Materials Handled in Tunnel

Muck removed upstream of Horetzky	3,560 cu. yds.
Muck removed from downstream through Horetzky	16,500 " "
Muck removed through 2600 level	16,300 " "
Aggregate produced and used	4,500 " "
Concrete Placed	5,000 " "
Gunite: Sand	1,100 " "
Gunite: Cement	8,000 bags

sets or steel arches being used in seven of these. Aside from the major cavern downstream, one location was improved with steel sets blocked with timber and covered with mesh and gunite.

The progress at the major cavern governed the completion of the work. The procedure is outlined in the section 'Actual Design—Major Cavern'.

The preparation to place the first stage concrete above the muck pile started July 8, and this protective concrete was completed August 1. The second bulkhead and concrete was completed August 10. The final steel set was installed August 23. The second stage concrete was poured by September 4, and the grouting completed September 6. The mucking was finished September 8. Cleanup and drilling of holes through to the cavern was finished and the tunnel filled on September 11.

Control by the consulting engineer was by means of a concrete laboratory at Horetzky, an inspector at the mixer, and several inspectors on all shifts in the tunnel. Particular attention was paid to ensure that seam chipping was carried far enough, that meshed areas were sufficient, that surfaces were thoroughly washed prior to guniting, and that sufficient depth and density of gunite was secured.

The cost of this work was $2,100,000.

Throughout, the word "seam" is used to apply to any band of soft or soluble material, in most cases the result of faulting. Regardless of the geological distinction between mylonite alone or gouge alone, all seams were considered.

Engineering Evaluation of Tunnel

An engineering evaluation of the tunnel after the repair and maintenance work includes the factors of future permanence and of the economics to date. In summary, there should be no future significant rockfalls, and in spite of the 1961 repair and maintenance cost, the unlined tunnel has been economical.

The troubles which occur in an unlined tunnel are due to the action of water on weaknesses in the walls of the tunnel. In the seven years of the Kemano tunnel operation the water has found the weaknesses and corrective measures have now been taken. A requirement for the 1961 repair and maintenance work was that it result in a permanent tunnel which would require no future shutdown. The repair of the main cavern, other rockfalls and actively eroding seams has been thorough and permanent.

There is no reason to expect future trouble from the concrete lined sections, unlined sections, or repaired tunnel. The only questionable area might be from unknown seams behind the original thin unreinforced gunite which were not exposed during the seven years of operation. The likelihood of trouble from this source is considered remote. Three improbable events which would have to combine to produce a future significant rockfall are:—

1. That several large seams or a group of small seams would still be hidden under the gunite. One seam would not represent a significant hazard. That a number together would not have some spots of spalled gunite after seven years of operation seems improbable. Small seams had in many places broken through the gunite and it seems improbable that many significant seams remain covered.
2. That a seam which did not break through the gunite in seven years will break through in the future. Seams which have remained sealed by the gunite for seven years have established a favourable record of stability under tunnel operation. All evidence is that the weak areas started developing early in the service of the tunnel, which indicates that the significant seams broke through the gunite shortly after tunnel filling.
3. That if a "break-through" occurred a major rockfall would result. The main cavern and the smaller rockfalls were caused by a large seam or numerous small seams. Such a seam or seams could not be expected to still be fully covered by the original gunite. If a portion of a seam "breaks through" it does not mean that the rest will, or that a fall will result. Many seams were substantially eroded without producing a rockfall.

The cost of the repair was unexpected and disappointing, but even in retrospect it does not make the original decision to use an unlined tunnel appear to be wrong. To have concrete lined the 7.2 mile length of unlined tunnel would have cost an additional $12,000,000, as compared with $1,100,000 (the 1954 value of the $2,100,000 cost on the basis of "present worth"), that could have economically been spent seven years earlier to avoid the repair cost. Lining this 7.2 miles would have delayed completion of the project at least four months. The Kemano tunnel experience makes it possible that future unlined tunnels can be more reliable and more economical, since repair and maintenance can probably be anticipated and avoided. The 3.3 miles of unlined and the 3.9 miles of unreinforced gunite tunnel performed without trouble, except where water action on erodible or soluble seams caused rockfalls. Sound rock tunnel walls which survive the tunnel blasting without excessive overbreak and which require no support should be satisfactory for an unlined tunnel, if erodible and soluble seams are adequately sealed.

Operation after 1961 Repair and Maintenance

With the units initially installed in 1954 flow was low and capacity limited. No check was made of the tunnel loss coefficient before rockfalls commenced.

The last three tests in Table I now show the loss coefficient to be about 0.68×10^{-5}, which is about 7% less than the originally calculated design coefficient. Thus, the tunnel will pass more than the calculated maximum flow of 4800 c.f.s.

The three "flushing tests" made in the 4.5 month period since refilling show a constant head loss.

Acknowledgements

The general contractor was Northern Construction Company & J. W. Stewart Limited of Vancouver. It is a pleasure to record the excellent performance of this contractor under President N. D. Lambert, with W. Grieve as General Superintendent.

The consulting engineer was G. E. Crippen & Associates Ltd. of Vancouver.

The tunnel consultant was J. Barry Cooke of San Francisco.

The consulting geologists were Dr. V. Dolmage and Dr. D. D. Campbell of Vancouver.

Aluminium Laboratories Limited served as hydraulic consultants on the tunnel, including testing and draining, and advised on geological aspects.

Hydraulic tests and studies were carried out by Aluminum Company of Canada, Limited and the whole operation was directed by Aluminum Company of Canada, Limited.

References

1. **ALCAN - NECHAKO - KEMANO - KITIMAT DEVELOPMENT.** Special Reprint from The Engineering Journal Nov. 1954 and April 1953, and **NECHAKO - KEMANO - KITIMAT** Hydro-Electric Power Development & Aluminum-Reduction Plant by F. L. Lawton & J. S. Kendrick. The Engineering Journal Sept. 1952.
2. **Installation & Operating Experiences with Kemano 2500 Foot Head Impulse Turbines** by J. T. Madill & F. P. Gordon. The Engineering Journal, Feb. 1958.

Discussion

KEMANO TUNNEL OPERATION AND MAINTENANCE

J. B. Cooke,
Consulting Engineer, San Francisco
J. W. Libby,
Asst. Chief Engineer and Vice-Pres., G. E. Crippen & Associates Ltd.
J. T. Madill, M.E.I.C.,
Assistant Manager, Power Division, Aluminum Company of Canada, Ltd.
The Engineering Journal, August, 1962, page
Discussion by J. O Gorman
Geology and Soil Mechanics Engineer
and W. R. Jenker
Hydraulic Design Engineer
The Hydro Electric Power Commission of Ontario

The paper gives an account of the first seven years of operation, 1954-1961, of the 10-mile long pressure tunnel at the Kitimat development of the Aluminum Company of Canada. Major repairs undertaken in 1961 which had become necessary after a series of major rock falls during the years 1956-1961 are described in detail.

The decision to line or leave unlined a hydraulic tunnel depends on many factors, geologic and economic. The experience gained at the Kemano Tunnel is a valuable contribution to the evaluation of this problem.

It is obvious that the critical unknown is the criteria for determining the rock conditions that are in themselves adequate and do not need lining. There is usually insufficient geological information available prior to tunnel driving to decide where to leave the tunnel unlined.

Weaknesses in the rock which demonstrate their instability during tunnelling operations are evident and decisions on lining or other forms of protection can be specified. However, other weaknesses which are only evident during operation of the tunnel are less evident and require suitable techniques for their detection which have yet to be fully developed.

At the time the decision was made to construct an unlined tunnel, the possibility of later repairs was undoubtedly taken into consideration. The actual extent, as well as the cost, of the repairs as undertaken appear to have been larger than anticipated, but to quote, "even in retrospect this does not make the original decision to use an unlined tunnel appear to be wrong". If the cost of repair is compared with the additional cost of complete lining, a rather large margin results in favor of an unlined tunnel.

However, in this comparison no account was taken of the fact that a completely lined tunnel, possessing essentially similar basic hydraulic performance characteristics as the unlined one, viz, the same head loss-discharge relationship, could be of substantially smaller cross-section. The savings in rock excavation for a lined tunnel were estimated and as a result the margin, although greatly reduced, was found to be still in favor of the unlined structure.

To complete the comparison, consideration must also be given to the economic losses due to a four-month delay in the completion of the project if the tunnel were lined. This four-month delay would, of course, be somewhat reduced since construction of the smaller cross-section would also reduce the time required for rock excavation. It appears somewhat difficult without further extensive studies to establish the time delay accurately and more so to put a realistic economic value on it. Since any allowance for economic losses due to delay would increase the margin in favor of the unlined tunnel, it would appear indeed that Alcan's decision to build the unlined tunnel has been correct.

In making an attempt to evaluate the experience for future application in a variety of different situations, it is suggested that the decision on lining or not lining will in each case also depend to a large extent on the nature of the enterprise constructing such works. It does appear that the soundness of Alcan's decision for the unlined tunnel hinges on the fact whether or not any operating losses were sustained during the five-year period, 1956-1961. Apparently Alcan's smelting and refining production requirements during those years were such that no serious power shortage was suffered. However, if for instance, a public utility were involved, the situation would be rather different. It is probably reasonable to assume that a utility would, in the first stage, install a generating capacity consistent with the full capacity of the one tunnel, i.e., 4800 c.f.s. Providing a liberal allowance of about 6% for outage and maintenance, 4500 c.f.s. could thus be utilized on an average annual basis. This flow would be available even in a minimum water year which yields 4490 c.f.s. Based on this assumption and on Alcan's discharge capacity measurements, operating revenue losses were estimated, including the losses during the period required for the major repair operation. The magnitude of these losses was such that taken together with the risk of a prolonged service interruption the decision for a public utility might be rather heavily influenced in favour of a lined tunnel.

The experience gained at Kitimat provides most valuable background for similar future undertakings. The writers were especially impressed with the ingenuity and resourcefulness revealed by the hydraulic investigations and the organization and execution of the repair work. The Aluminum Company of Canada is to be commended for making their experience gained with this project available to the engineering profession.

(Continued on page 70)

Greetings
From
Sister Societies

In recognition of the 75th Anniversary of the Engineering Institute of Canada, congratulations were offered by many sister societies around the world. Many of these were in the form of beautifully intricate scrolls. Technical difficulties forbid the reproduction in colour of these messages, but four of them which have been reproduced in black and white on the following pages are typical.

These scrolls and messages were on display at the Queen Elizabeth Hotel in Montreal during the 75th Anniversary Annual General Meeting of the Institute in June. For the remainder of the Anniversary Year many of these messages will be on display at Institute Headquarters.

The Engineering Institute of Canada is proud and grateful of its firm association with the learned and technical societies of the world.

Agricultural Institute of Canada
American Chemical Society
American Concrete Institute
American Institute of Chemical Engineers
American Institute of Electrical Engineers
American Institute of Mining, Metallurgical, and Petroleum Engineers
American Society for Engineering Education
American Society for Metals
American Society for Quality Control
American Society for Testing and Materials
American Society of Agricultural Engineers
American Society of Civil Engineers
American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc.
American Society of Mechanical Engineers
American Society of Safety Engineers
American Railway Engineering Association
Arctic Institute of North America
Association des Ingenieurs et Architectes Haitiens
Brazilian Federation of Engineering Associations
Canadian Aeronautics and Space Institute

Canadian Association of Physicists
Canadian Council of Professional Engineers
Canadian Institute of Mining and Metallurgy
Canadian Mathematical Congress
Canadian Pulp and Paper Association
Centro Paraguayo de Ingenieros
Dansk Ingeniorforening
Engineers' Council for Professional Development
Engineers Joint Council
Hungarian Canadian Engineers' Association
Institute of the Aerospace Sciences
Institute of Engineers (Pakistan)
Institution of Civil Engineers of Ireland
Institution of Engineers (Australia)
Institution of Chemical Engineers (Britain)
Institution of Engineers (Ceylon)
Institution of Engineers (India)
La Sociedad Cubana de Ingenieros
National Academy of Science of the United States
National Council of the State Boards of Engineering Examiners
National Society of Professional Engineers
New Zealand Institution of Engineers
Norwegian Society of Engineers
Ordem dos Engenheiros (Portugal)
Royal Architectural Institute of Canada
Royal Canadian Geographical Society
Royal Institution of Engineers in the Netherlands
Royal Society of Canada
Sociedad Colombiana de Ingenieros
Societe Royale Belge des Ingenieurs et des Industriels
Swiss Society of Engineers and Architects
South African Institute of Electrical Engineers
South African Institution of Mechanical Engineers
Svenska Teknologforeningen
Swiss Association of Professional Engineers and Architects
Tekniska Foreningen
Verein Deutcher Ingenieure

The Presidents, Councils and Members of
THE INSTITUTION OF CIVIL ENGINEERS,
THE INSTITUTION OF MECHANICAL ENGINEERS and
THE INSTITUTION OF ELECTRICAL ENGINEERS
SEND GREETINGS to the President, Council and Members of

THE ENGINEERING INSTITUTE OF CANADA

on the occasion of the celebration of the seventy-fifth anniversary of the foundation of the Institute, and have great pleasure in conveying sincere and cordial congratulations upon this memorable occasion.

THE Institute has, during the past 75 years, maintained the highest standards in the Engineering profession and most worthily fulfilled the objects for which it was established.

THE Members of the Three Institutions gladly welcome this opportunity to convey an expression of their cordial good wishes for the continued welfare and prosperity of the Engineering Institute of Canada and trust that the close and friendly relations which have always existed, may long continue in the interest of the continuing advance of Engineering achievements and research in the service of mankind.

WITNESS our hands and Seals at Westminster this fourteenth day of May, One thousand nine hundred and sixty two.

The Institution of Civil Engineers | The Institution of Mechanical Engineers | The Institution of Electrical Engineers

President | President | President

Secretary | Secretary | Secretary

The American Society of Civil Engineers

presents this

Scroll of Honor

with greetings and felicitations to

The Engineering Institute of Canada

on the occasion of its

75th Anniversary

The distinguished service that has been rendered mankind and the engineering profession over the years is a lasting monument, universally recognized. May your future be rewarding in even greater accomplishments toward the benefit of humanity.

June 13, 1962

G. Brooks Earnest
President

W. H. Wisely
Secretary

The South African Institution of Civil Engineers

May it please
The Engineering Institute of Canada
on the occasion of its
Seventy-fifth Anniversary
to accept the cordial greetings of
The
South African Institution of Civil Engineers

Our Institution congratulates the
Engineering Institute of Canada
on 75 years of notable achievement and is
confident that it will continue to make
valuable contributions to the
advancement of civilization

PRESIDENT

Johannesburg
June 13, 1962

Seventy-five years ago

The Engineering Institute of Canada

was founded

Since that time it has made a magnificent contribution to the practice of engineering in Canada.

Accordingly it is with fraternal affection that The Chemical Institute of Canada presents these Anniversary Greetings.

June 13, 1962

L. H. Cragg
President

[signature]
Secretary

TECHNICAL PAPERS FOR THE 1963 ANNUAL GENERAL MEETING

Those wishing to submit technical papers for presentation at the Annual Meeting in Quebec City, May, 1963, are reminded that the deadline for submission of papers is January 31, 1963.

Abstracts of the papers to be submitted should be sent without delay to the Chairmen of the Divisions concerned for consideration. These should be addressed to the appropriate Technical Division of the C.T.O. as follows:

CIVIL ENGINEERING: Dr. R. M. Hardy, Hon. M.E.I.C., 10214-112th St., Edmonton, Alta.

BRIDGE & STRUCTURAL: A. M. Bain, M.E.I.C., c/o Dominion Bridge Co. Ltd., P.O. Box 280, Montreal, Que.

GEOTECHNICAL: Dr. R. F. Legget, M.E.I.C., National Research Council, Ottawa 2, Ont.

MINING & METALLURGICAL: Dr. R. P. Charbonnier. M.E.I.C., Senior Scientific Officer, Dept. of Mines & Technical Surveys, 562 Booth St., Ottawa 4, Ont.

CHEMICAL ENGINEERING: Dean G. W. Govier, M.E.I.C., Faculty of Engineering, University of Alberta, Edmonton, Alta.

MECHANICAL: Professor A. R. Edis, M.E.I.C., Department of Mechanical Engineering, McGill University, Montreal, Que.

WELDING: (No Chairman appointed as yet—send papers to Mechanical Division.)

THERMAL POWER: D. L. Harris, M.E.I.C., Chief Engineer, Mechanical Services & Thermal Division, Shawinigan Engineering Co. Ltd., 620 Dorchester Blvd. W., Montreal, Que.

HYDRO-ELECTRIC: J. A. Thomas, M.E.I.C., Shawinigan Engineering Co. Ltd., 620 Dorchester Blvd. W., Montreal, Que.

ELECTRICAL: A. J. Girdwood, M.E.I.C., Chief Engineer, Leland Electric Canada Ltd., Guelph, Ont.

COMMUNICATIONS, ELECTRONICS & AUTOMATION: Professor G. S. Glinski, M.E.I.C., Dept. of Electrical Engineering, University of Ottawa, Ottawa, Ont.

ENGINEERING EDUCATION: Professor A. Porter. M.E.I.C., Dept. of Industrial Engineering, University of Toronto, Toronto, Ont.

MANAGEMENT: W. L. Hutchison, M.E.I.C., Moffats Limited, Weston, Ont.


IMPERIAL
Esso
PRODUCTS
Esso MP
GREASE
H
For
Industrial
Automotive
Agricultural
Uses
Imperial research made lubrication easy and simple . . . free from waste and mess
Esso MP Grease Cartridges contain refinery-clean grease, free from open pail contamination, waste and mess...and gun loading takes only 20 seconds...that adds up to correct lubrication, the easy and simple way.
Five grades of Esso MP Grease are now available in cartridges: "H" for general use, "M" for lower temperatures, "EP" for extreme pressures, "Moly" for extreme pressures and intermittent motion and "Lotemp Moly" for very low temperatures.
The latest information on lubricants and fuels for industry is available to you through the trained Imperial Industrial Sales Representative. Just call the nearest Imperial Oil Office.
ALWAYS LOOK TO IMPERIAL FOR THE BEST

Canadian Developments

FIRST CO-OP ENGINEERS

On July 7, 1962, a group of pioneering university students received Bachelor of Applied Science degrees from the University of Waterloo. These are the students who were among the first to enrol in the University's co-operative engineering program inaugurated in July, 1957.

The University of Waterloo's co-operative program called for alternating academic terms on the campus with on-the-job training terms in industry for practical experience, with one group at the university while the other was in industry. In this way, the University felt it could offer a well-rounded program of professional training and education, obtain year-round use of university facilities and maintain a sizable enrolment without sacrificing academic standards.

When the first students enrolled, the university had no background in engineering education, only a handful of faculty members, limited classroom and laboratory space and only a few books. At the time, Waterloo did not have a university charter.

The University of Waterloo is now fully accredited and recognized. The Engineering enrollment is one of the largest in Canada, and ever since the program began, industry has co-operated by employing the students for their training terms.

There were approximately 70 men in the University's first graduating class. The majority of these have accepted positions in industry and in most cases with companies which have been participating in the co-operative program.

Dr. Harvey R. L. Streight, principal chemical engineer with DuPont of Canada's Engineering Department, was awarded an Honorary Degree of Doctor of Science (D.Sc) at the University of Waterloo.

Dr. Streight's industrial career began with Imperial Chemical Industries in England. He joined Canadian Industries Limited in 1937, and in 1954 became a member of DuPont of Canada's engineering Department. Dr. Streight is a former director of the Chemical Institute of Canada; and has been an active member of the Canadian Standards Association. In 1959 he was awarded the Plummer Medal of the Engineering Institute of Canada. Dr. Streight, together with his company, is a holder of a number of patents in several countries. Dr. Streight is active in church and charitable organizations.

First Engineering Degrees at RMC

Three outstanding Canadian engineers were awarded honorary degrees during the June 1 convocation at the Royal Military College, Kingston. And for the first time in the College's history, engineering degrees were awarded.

The College received degree-granting power in 1958, and all cadets who graduated in Arts and Science since its re-opening in 1948 have received BA or BSc degrees.

The engineers awarded honorary degrees were: Dr. John Bertam Stirling, Hon. M.E.I.C.; Lt.-Col. L. F. Grant, M.E.I.C.; and Professor H. H. Lawson. Dr. Stirling and Col. Grant are past Presidents of the Engineering Institute of Canada. Professor Lawson, an RMC graduate himself, was a member of the College staff for 25 years.

At the convocation, 131 young officers received degrees, 58 in engineering, 39 in science and 34 in arts.

LAKEVIEW OPENS OFFICIALLY

The Lakeview thermal-electric power station at Toronto, which by 1966 will have a generating capacity equal to Ontario Hydro's two major Niagara River developments, was officially opened earlier this summer.

The coal-fired Lakeview Generating Station, costing an estimated $217 million, marks an important step in Ontario Hydro's long-term planning to meet future power demands.

Construction of the Lakeview station began in June, 1958, and the first 300,000 kw. unit produced energy for the province in October, 1961. By 1966, Lakeview will have a capacity of 1,800-000 kw., enough to supply more than one million homes.

Automation plays an important role in promoting cost-saving and efficiency at the Lakeview plant. Two self-unloading coal carriers can tie up simultaneously at the 2000 foot dock which juts into Lake Ontario, and discharge their cargoes into hoppers. A belt travelling at 630 feet per minute, carries the coal at 2000 tons per hour, through a weatherproof dock tunnel to huge conveyors that spread coal on a massive storage pile. From there, a smaller con-

(Continued on page 60)

This photograph was taken at the June 1 Convocation at RMC. From the left: Lt.-Col. L. F. Grant, M.E.I.C.; Dr. J. B. Stirling, Hon. M.E.I.C.; Brigadier G. H. Spencer, M.E.I.C., Commandant of RMC; and Professor H. H. Lawson.

(Continued from page 58)
veyor carries the coal into the powerhouse where it is pulverized and blown into the high steam generator.

Steam, heated and reheated to 1000 degrees Fahrenheit, drives the first six 300,000-kilowatt turbo-generators, the largest in Canada. Each of the plant's boilers will be capable of producing 2,000,000 pounds of steam an hour.

At full operation, the plant will draw condenser cooling water from Lake Ontario at a rate of more than one million gallons a minute. The water will be returned to the lake unpolluted. Each unit will burn more than 100 tons of coal an hour.

ROLPHTON ON POWER

The first electricity to be produced by a nuclear power plant in Canada was sent into the transmission lines of Ontario Hydro at Rolphton, Ont., at the beginning of June. Commissioning of the Nuclear Power Demonstration Station has been under way since the reactor in the station first started to "burn" uranium, and thus to produce heat, on April 11, 1962. The next stage was to use heat from the reactor to produce steam.

Finally, with all the complex circuits fully tested, the plant operators opened the steam circuit to the turbine which drives the electricity generator, sending electricity produced from the reactor to produce steam. The station is expected to produce its full power output of 20,000 kilowatts of electricity within the next few months.

Heavy water is used in the NPD reactor to enable the uranium to "burn" and also to transfer heat from the reactor to the steam generator, where ordinary water is converted to steam. A question often raised has been whether or not the losses of expensive heavy water could be kept sufficiently low by development of leak-tight joints in piping and by designing systems to catch any heavy water that might escape. Heavy water losses to date have been well below the limits set by the plant designers.

A prototype for larger plants, such as the 200,000 kilowatt Douglas Point Nuclear Power Station now under construction on the eastern shore of Lake Huron, the $33 million NPD station was built as a co-operative project of the Atomic Energy of Canada Limited, Ontario Hydro and Canadian General Electric Company Limited.

SASKATCHEWAN REUNION

A 50th Anniversary Engineering Reunion sponsored by the University of Saskatchewan Alumni Association and the College of Engineering will be held in Saskatchewan on October 5-6.

The program will include two papers. Dr. Neil B. Hutcheon, '33, Assistant Director, Division of Building Research, National Research Council, Ottawa, will discuss "Research". Charles C. Hay, '25, President, Royalite Oil Company, Calgary, will talk on "Industry". These papers, to be presented on the morning of the fifth, will be followed by a stag luncheon at the Bessborough Hotel.

The afternoon program will include the official opening of an addition to the engineering building. The speaker will be Dr. C. J. Mackenzie, Dean of Engineering from 1921 until 1939, and former President of the National Research Council, Ottawa. A conducted tour of the engineering building and research areas will be held. In the evening there will be a mixed reception, a banquet and a dance at the Bessborough Hotel.

Saturday's program includes the Students' Alumni Homecoming Parade, an Intervarsity football game between the Huskies and the University of Alberta Golden Bears, and a post game Alumni Party.

PETROLEUM TECHNOLOGY

A handsome new journal designed to disseminate and preserve current literature on the technology of the Canadian petroleum and natural gas industry has been introduced. Called "The Journal of Canadian Petroleum Technology" it is being published quarterly by the Petroleum and Natural Gas Division of the Canadian Institute of Mining and Metallurgy.

Primarily, the journal will publish papers presented at annual technical meetings or other meetings of the Petroleum and Natural Gas Division.

GRAND RAPIDS PROJECT

Several features, unique in the power development construction field, are being encountered in the construction of the $140 million Grand Rapids Project by Manitoba Hydro. Now in the rock excavation stage, the project will require the construction of 16 miles of earth dike calling for nine million cubic yards of fill material. This will be used to form a forebay reservoir covering approximately 2,000 square miles and will be one of the largest lakes in Manitoba.

The most critical aspect of the project was dependent upon the success of controlling bedrock seepage through the porous limestone. The project area is covered with shallow, glacial-derived overburden. Many surface depressions, indicative of sink holes underground, and numerous springs were the main indications of substantial flow through the loose honeycomb-like mass of bedrock. The most practical method of preventing excessive leakage from the reservoir would be the construction of a grout curtain. This meant grouting a waterproof fence up to a depth of 200 feet beneath the floor along 16 miles of dike, the largest grouting operation ever attempted.

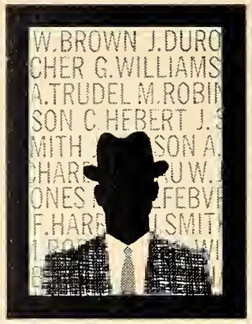
EHV IN ONTARIO

An extra-high-voltage (EHV) line, designed to carry electricity farther and in greater quantity than any transmission line in Ontario, is under construction between James Bay and the Sudbury area, a distance of 230 miles. New V-shaped towers, Canadian-designed and manufactured, are being used for the first time by Ontario Hydro. Each tower carries 12 conductors, or lines, arranged in three squares or bundles.

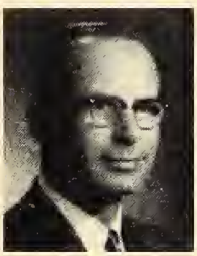
Extra-high-voltage has been the key factor in the development of the rich potential of low-cost power in the far northern reaches of Ontario. Tests conducted over an experimental line established the most economical method of transmission would be at voltages around 500,000. This would provide more than four times the power-carrying capacity of the 230,000 volts lines now used by Ontario Hydro.

By 1966, more than 500,000 kilowatts of electricity from four new plants on the James Bay watershed will be moving to a central collection point at the northern end of the line for transmission to southern markets.

Personals



Charles T. Meredith, formerly Sales Representative for Anaconda American Brass Limited in Eastern Canada, has been appointed Eastern Sales Manager, succeeding **Donald F. Cornish** who has been appointed Assistant Sales Manager with headquarters in New Toronto.



Donald F. Cornish

Charles T. Meredith

Lloyd G. Brown formerly Label Service Supervisor at Underwriters' Laboratories of Canada has been appointed resident inspector at Winnipeg and will serve as the ULC inspector and general representative for the Prairie provinces. **John Vilim,** formerly inspector at Winnipeg, has been transferred to Montreal and will be responsible for inspection activities in Quebec. **David S. Martin** will assume the newly created post of Chief Engineer.

Theo M. Parr, M.E.I.C., has been appointed a vice-president of Canadian Ingersoll-Rand Company Limited. Mr. Parr joined the company in 1927. In 1960 he was appointed to act in an executive capacity on sales and service. In 1961 he was appointed a director of the company.

Theo M. Parr

Lars J. Firing

Lars J. Firing has been appointed President and General Manager of Reductioneering Limited. Mr. Firing has had an extensive background in process engineering and production management.

George L. Olts has been appointed Manager of the Building Division, and James D. Jarrell as Comptroller at Perini Limited, Toronto. **A. D. McKee, W. M. Doyle** and **D. R. Hinton** have resigned their positions to form their own general contracting firm, McKee, Doyle, Hinton Limited, with head offices in Toronto.

Earl C. Findlay has been named Vice President-Technical Director for Canadian Zurn Industries Ltd. Mr. Findlay has had more than 25 years engineering and technical sales experienee in the fields of mechanical power transmission and fluid handling. Mr. Findlay will coordinate engineering and sales functions of the Canadian Zurn Fluid Control and Mechanical Power Transmission Divisions. Mr. Findlay will be located at the company's offices in Toronto.

Earl C. Findlay

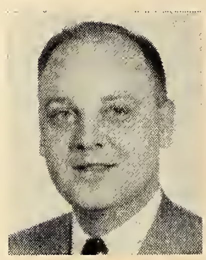
A. J. Poynton

A. J. Poynton has been appointed Superintendent of the Shell Oil Company of Canada's Montreal East Refinery. Mr. Poynton joined Shell in 1957 as a technologist in the Topping and Thermal Cracking Department. Prior to his present assignment, he was chief technologist of the Montreal East plant.

R. J. Lerou has been appointed Vice President Sales Promotion and Engineering at Josam Products Limited, Toronto. **C. H. Swanson** has been appointed Vice-President Production and Purchasing for the firm.

Peter M. Titcombe has been appointed Sales Engineer in Ontario for Dominion Bridge Company's Mechanical Division. Mr. Titcombe has considerable sales and engineering experience. He will be located in Toronto.

John R. M. Szogyen-Delmar, M.E.I.C. (U.B.C. '51) formerly in charge of Rotating Machine Engineering with English Electric Canada, Toronto, has become Chief Electrical Engineer with Electro Dynamic in Bayonne, N.J. Mr. Szogyen-Delmar has been chairman of the Canadian Standards Association Committee on Rotating Electrical Machines, is a member of the American Institute of Electrical Engineers and the Association Suisse des Electrician.



D. D. Richardson

J. R. M. Szogyen-Delmar

D. D. Richardson has been appointed Assistant Vice President assuming additional responsibilities in the Materials Handling Division of International Equipment Company Limited. In his present capacity he will continue to direct the sales of the company in Quebec and the Maritimes. **B. O. Glenn** has been appointed Assistant Vice President in Calgary, and will continue to direct the activities of the Western Branches of the company.

Morley G. Taylor, M.E.I.C. (N.S.T.C. '27, M.I.T. '31) was recently appointed President of Canadian International Power Company Limited. Mr. Taylor is also President and Chief Executive officer of International Power Company Limited.

E. de Haas, M.E.I.C. (Delft. '46), formerly Head of Electrical and Mechanical Engineer with the 3BEV Accelerator Project at Princeton University, has joined the Radio Corporation of America, Astro Division in Princeton. This Division is concerned with the design and manufacture of spacecraft, and as Senior Engineer in Advanced Power Systems, Mr. de Haas' work will consist of the design of electrical systems for satellites, spaceprobes and space stations, both manned and unmanned.

N. A. Eager, M.E.I.C. (McGill '22, Cornell '23) has been appointed Vice-President and Director of Slater Steel Industries Limited.

R. K. Thoman, M.E.I.C. (Queen's '36) has been appointed President, Burlington Division and Vice-President of the Slater Steel Industries Limited.

Ivan F. Ronalds, M.E.I.C. (U.N.B. '41) has been appointed Vice-President in charge of the Vancouver office of Foundation of Canada Engineering Corporation Limited (FENCO). He was previously in FENCO's Toronto office as Division Engineer, Mining and Metallurgy. Mr. Ronalds has also had extensive experience in design and construction in the fields of transportation and hydro-electric power. He is a member of the consulting practice committee of the A.P.E.O.

H. C. Rynard, M.E.I.C. (Toronto '51) has been appointed Manager of the new Montreal offices of H. G. Acres & Company Limited, International Consultants with head offices in Niagara Falls, Ont. Mr. Rynard joined the company in 1951, and in recent years has filled senior engineering and management positions with the firm on industrial, municipal, transportation, hydro-electric and thermal-electric power supply projects. Mr. Rynard is a Director of H. G. Acres & Company Ltd., Acres International Limited, and a partner in the firm of Simpson, Travers & Associates.

Lewis W. Vaughan, M.E.I.C. (Toronto '50), formerly Engineering Supervisor at Underwriters' Laboratories of Canada, has been appointed Assistant General Manager. Mr. Vaughan has been a member of the ULC staff since 1950.

E. A. Ford, M.E.I.C. (Manitoba '27) has been re-elected President of the Canadian Institute of Steel Construction. The C.I.S.C. is a national organization representing the structural steel and plate fabricating industries.

W. J. McNicol, M.E.I.C. (U.B.C. '50) has been appointed manager of the Canadian Westinghouse Manufacturing and Repair Division. He was previously apparatus sales manager for the company's Ontario district.

Donald I. McGillivray, M.E.I.C. (Queen's '37) formerly Inspection Engineer at Underwriters' Laboratories of Canada, has been assigned the newly created title of Chief Inspector with full responsibility for inspection operations at factories producing ULC listed equipment.

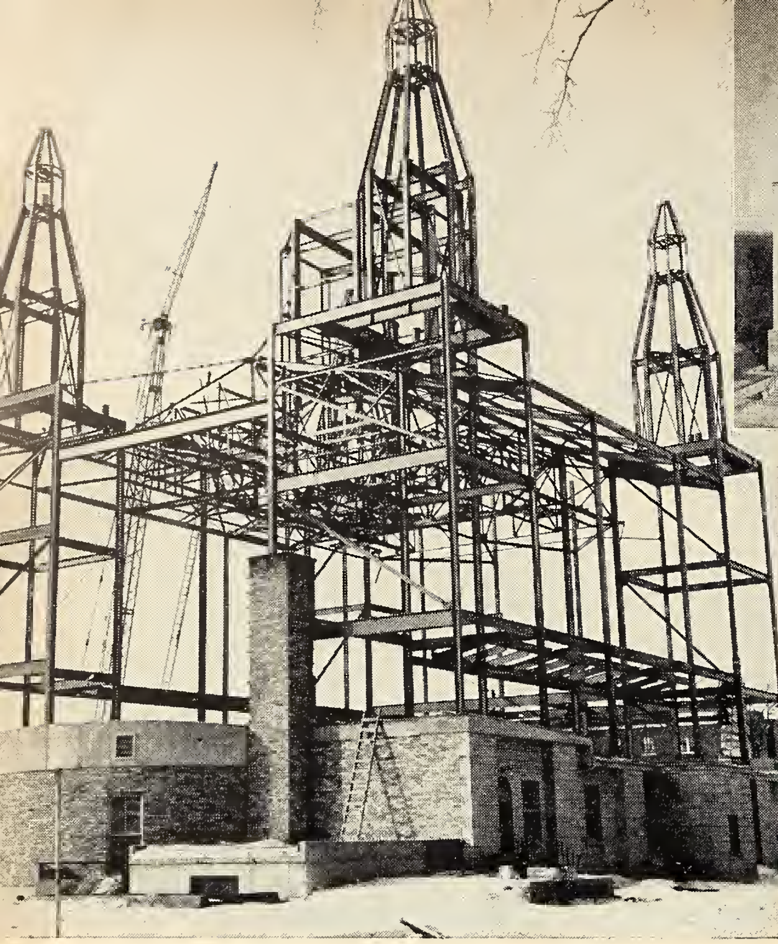
Earl C. Findlay has been appointed Vice-President and Technical Director of Canadian Zurn Industries Limited, a subsidiary of Zurn Industries Inc., Erie, Pa.

R. F. U. Icely has been appoined assistant plant manager at Union Carbide Canada Limited's Chemicals and Plastics Division, Montreal East installation. Mr. Icely has been associated with the division since 1956 as works engineer.

Obituaries

John Van Nostrand Dorr (Rutgers '94) died June 29 in a Connecticut hospital. He was 90. Mr. Dorr was a pioneer in chemical engineering, and is credited with early applying chemical engineering principles to extractive metallurgy and generally with hastening the transition from intermittent to continuous operation. This facilitated mass production in many industries. A founder or partner in many companies, Mr. Dorr was Chairman Emeritus of Dorr-Oliver Incorporated, an internationally-known engineering firm.

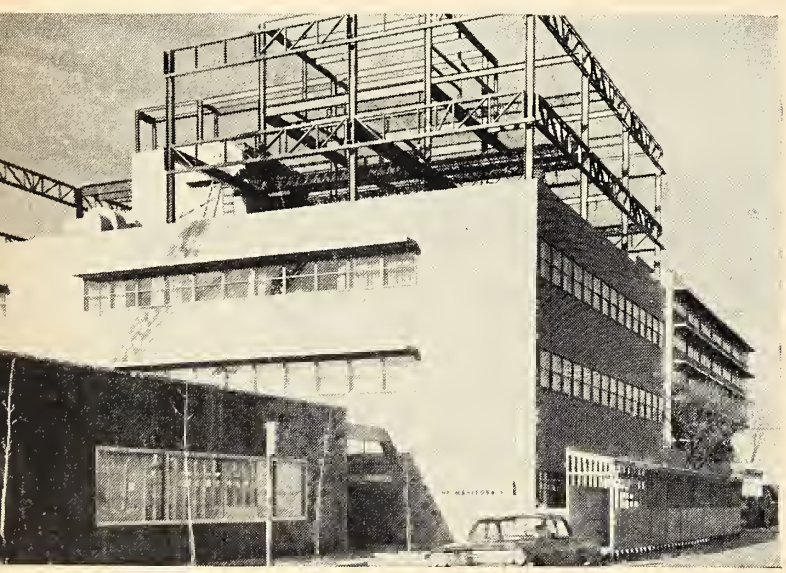
EIC



Steel is versatile

Structural steel can be used to build complex desig shapes. This steel frame is for the Greek Orthodo Holy Trinity Cathedral in Winnipeg and inset i the finished building.

Architects: Green, Blankstein, Russell & Associates.



Additions are easy with steel

When this building was first constructed two extr floors at a later date were a possibility. Last yea they became a reality. The tops of the main suppor columns of the original steel frame had been lef exposed and the new steel was added quickl and economically.

Architects: Smith, Carter, Searle & Associates.

Castellated steel beams reduce weight

The use of castellated beams in the C.N.E. Hom Furnishing Building in Toronto resulted in roo purlins that were about 75% of the weight of a equally strong rolled beam and about 60% of th weight of an equally rigid rolled beam. Beams ar castellated by cutting the web zigzag fashion offsetting the halves one notch and rewelding peak to peak. Castellated beams can free the designe from the restrictions of excessive deflections whe using the new high strength steels.

Architects: Marani, Morris & Allan.
Consulting Structural Engineer: W. Sefton & Associates, Limited.

News of the Branches

AMHERST

G. C. L. McEnery

On June 8, 20 members and one guest, Ton Verhaeyen, a Dutch student employed by Robb Engineering Works for the summer, attended a meeting held by the Branch.

W.D. Hagen, Chairman of the Branch, reviewed the growth of the Engineering Institute of Canada from its formation in 1887, to the present day when it comprises about 23,000 members in some 70 Branches across Canada.

In connection with the 75th Anniversary of the Institute, Lew Burrill gave a report of engineering developments in the Cumberland area from the days of the Acadians to the present day. Mr. Burrill's address also covered engineering developments in other areas. He spoke about the first electrical power transmission using a pit-mouth operation in 1889, the authorization of the Chignecto Canal Co. in 1882 by the Federal Government and gave a brief outline of the contract awards and construction procedures until abandonment of the project in 1891. A history of the salt industry in the Amherst-Pugwash district, and the history of the Robb Engineering Works from its beginning as a sheet metal shop, to its present status as one of the largest erectors and steel fabricators in the Maritime area, were also included in Mr. Burrill's address.

BROCKVILLE

A. N. Campbell

D. S. Caverly, Assistant General Manager, Ontario Water Resources Commission, Toronto spoke to the May 30 meeting of the Branch. In his talk entitled "Water Pollution", Mr. Caverly dealt with water supply and waste disposal problems and described the single program which the Commission has found necessary in meeting these problems. He discussed the creation of the Commission in 1956, outlined its functions and responsibilities and showed the part the Commission plays in Ontario's public life. The Water Resources Commission ensures the maintenance of public water supplies in safe condition for domestic consumption. It also assists in enabling municipalities to finance improved water and sewage treatment works. Mr. Caverly's talk was illustrated with color slides, and was followed by a question and answer period.

The members of the Branch were told of the success of the 1962 Leeds and Grenville Science Regional Fair which they sponsored with the local braneh of the Chemical Institute of Canada. The Fair had been the first such effort in this district and attracted 30 entries. The top four entries of this Fair, held February 24, were entered in the Canada-wide Science Fair in Ottawa, where they competed with 45 other regional winners from across Canada. Roger L. Hudgin, Grade 12 student, and David H. Swerdfeger, Grade 13 student won second and third place in the Biological Sciences and Physical Sciences Divisions in Ottawa. The other two entries were awarded honorary mention in the Physical Sciences Division. It is anticipated that the 1963 Fair will be an even greater success.

CORNWALL

Fred R. Warner

John G. Powell, Municipal engineer with Gore and Storrie, Toronto engineering consultants planning the proposed sewage disposal plant, was the guest speaker at the May 3 meeting of the Branch. Mr. Powell outlined the local soil conditions and sewage reuirements, various stages of development and total installation plant, and the results of similar plans now in operation. The disposal system will cost approximately $4,200,000. Mr. Powell pointed out that it is unlawful to pollute natural waters. The sewage scheme consists of a huge interceptor sewer turning eastward to the pumping station in East Cornwall. A cement tunnel, 30 feet below ground will wend its way to the actual disposal plant where the wastes will be processed and released into the river, 500 feet from shore between the north river bank and Pilon Island. The sludge removed from the waste will be treated with a bacteria which reduces it to the extent it can be sold as a soil conditioner.

The plant will be capable of handling waste from a city of 60,000 people. The plant will process 7,500,000 gallons of waste per day. It is a primary treatment installation, considered quite adequate for Cornwall. The system is designed to handle expansion within the city limits for years to come.

Mr. Powell advised that it would be best if industry did not use the system since this would put too great a strain on the machinery. A series of colored slides concerning the local installation and several similar plants across the province were shown. The plant will be landscaped in order to keep it as private as possible. Mr. Powell stressed that plants of this type produce no odor.

Mayor N. Kaneb, Alderman Rheal Lemire, chairman of Cornwall's Health and Sanitation Committee, and R.C. Adams, city engineer were present at the meeting.

ESTEVEN

O. P. Lesiuk

On May 7, B. Hewes, Manager at Caproco, Calgary, spoke to a meeting of the Branch. The topic of his speech was Corrision Causes and Prevention. He outlined in detail the basic causes of metallic corrosion, and gave examples of corrision progress in down-hole casings, pipelines, storage tanks, and general outfield equipment. Mr. Hewes then discussed methods for the prevention and reduction of corrosion. A lively discussion followed the talk.

W. Daniels, representative for James Richardson & Sons, Regina, Sask., was the guest speaker at the Branch's June 4 meeting. He discussed the procedure of the stock market, the positon of the stock broker, and reviewed various types of investments.

A golf tournament and barbeque were held June 20, closing the meeting for the season. The next Branch meeting will be September 4.

TORONTO

R. Paganelli

The Toronto Branch has announced ambitious plans for its 1962-63 Professional Development Program. This program, sponsored by the E.I.C., consists of evening lectures designed to enable engineers to further their general education in non-technical subjects such as philosophy, politics, labor relations and art.

The program is spread over a three-year period with most members progressing from Group I through Group III. Following are the subjects which will be covered in each group.

Group I: speech communications, how to listen, banking, personal investment, new industrial society, new concepts in education, health for the executive, psycology, labor relations, law, philosophy, physical fitness.

Group II: sales merchandising; metropolitan planning and traffic, politics, operations research, metropolitan gov-

(Continued on page 69)

ernment, mental health case studies, computer applications, engineering in Russia, labor relations, Quebec separatist movement.

Group III: Canadian foreign affairs case studies, company finance, art, reformatory institutions, computer applications, Canada in world markets, advertising, personal investment, cause and treatment of mental illness, conservation, civil defence, marketing, visit to a modern plant.

WINNIPEG

P. A. Brett

The final technical meeting for the 1961-62 season was held April 5. J. L. Olson of the Atomic Power Department, Canadian General Electric Co. Ltd., gave a talk entitled, "Progress on Nuclear Power in Canada". Mr. Olson discussed several aspects of the Rolphton and CANDU projects, and pointed out the manufacturing problems involved in the production of components for atomic power projects. Mr. Olson's comments on the organic tester for the local Whiteshell Project were of particular interest to the Branch's Electrical Section. Colored slides were used to illustrate this very interesting talk.

On April 24, Dr. K. G. Standing of the Physics Department, University of Manitoba gave a talk on cyclotrons and in particular, the partially completed cyclotron at the University. The members of the Branch visited the University, where they were able to see the internal operations of the cyclotron.

The annual Smorgasbord and Dance held on May 4 ended the season's meetings. All the events were well attended and proved very enjoyable to all members and guests.

EIC

COMING EVENTS

The Institution of Electrical Engineers, North Eastern Centre. Symposium on Magnetoplasmadynamic Electrical Power Generation. King's College, University of Durham, Newcastle upon Tyne, England. September 6-8.

The Institution of Electrical Inspection. Annual National Inspection Conference. New College, Oxford, England. September 25-27.

The Interamerican Federation of the Construction Industry. 3rd Interamerican Congress of the Construction Industry. Rio de Janeiro, Brazil. September 10-16.

American Chemical Society. Division of Rubber Chemistry. New York. September 10-13.

American Society of Mechanical Engineers. Petroleum Mechanical Engineering Conference. Tulsa, Okla. September 22-25.

American Society of Mechanical Engineers, American Institute of Electrical Engineers. National Power Conference. Cincinnati, Ohio. September 23-25.

Institute of Radio Engineers. Sixth Canadian Convention. Toronto, October.

(Continued from page 48)

Discussion by
N. D. Lambert, M.E.I.C.,
Northern Construction Co.
& J. W. Stewart Limited.

In the first place, I would say that I am in thorough accord with the exposition and explanation of the means taken to determine the nature and location of the principal obstruction in the tunnel which proved surprisingly accurate and was of great value in determining the pre-planning of equipment required. All the preliminary discussions were borne out in actual practice as to the nature of equipment required, and the only unforeseen factor was an approximate three-fold increase in the total amount needed, not any material change in its nature.

One subject that I feel has been inadequately discussed in the paper is the matter of ventilation which proved, to my mind, to be the limiting factor in carrying out the necessary repairs. This became a much greater problem than anticipated due, in the first place, to the greatly increased utilization of internal combustion equipment which was either gasoline motor power converted to propane burning or diesel units furnished with scrubbers. The ventilation problem was also intensified due to the length of the tunnel, which had only three sources of air circulation; the discharge at the 2600-ft. level which was in the relatively moist humid climate—the Coast; the Horetzky adit—which drew its fresh air supply from the relatively chilly mid-Coast Range area; and the intake, which was to the east of the Coast Range in a much drier climate. These conditions caused a variable circulation of air in the tunnel which, at times, entirely reversed its flow. The ventilation problem was complicated by the necessity to install scrubbers on the diesel powered equipment, which tended to create a dense smog, and the fact that all equipment had to be operated by internal combustion engines. Even if electric motors were used, electricity had to be generated by motor generator sets. Furthermore, the source of fresh air for both upstream and downstream operations had to be the Horetzky adit.

As the ground dried out after the tunnel was unwatered, the hazard from falling rock became more and more acute until the method had to be devised, which is described in the paper, to carry out the installation of steel sets and forms throughout the main cavity without exposure of personnel and the installation of a through conduit for ventilation was an essential part of this operation.

I would also like to point out that my personal feeling is that undue emphasis has been placed on the value of unlined tunnel. It is not apparent from the paper whether the $12,000,000 mentioned is the present value of the advantage of the unlined tunnel over the lined, or whether that refers to costs at the time of construction. I think the statement made would have more validity if it were broken down to provide a more detailed study of the comparative costs. Of course, it must be borne in mind that a lined conduit has a much less cross sectional requirement than an unlined. Furthermore, it should be pointed out that this repair could not possibly have been carried out in less than double the time actually consumed if it had not been for the paved invert, which was practically undamaged.

Discussion by
M. Murchison, M.E.I.C.,
Supervising Engineer,
Montreal Engineering Company Ltd.

1. During the planning of the repair operation and when it was known that there was a major blockage over a limited length of tunnel, was the alternative of a new tunnel round the cavern area considered? If concrete plugs were set in the original tunnel, say 300 feet part, a lot of the muck eould have been left between the plugs and not hauled out. This solution would appear to be faster, more straightforward and, at first glance, cheaper. Could the authors enlarge on the arguments for or against such a scheme.
2. From the third last paragraph under the heading, "Inspeetion", it is understood that none of the areas in which rock falls occurred were originally gunited. Would the authors please confirm if this was the case and, if so, what was the reasoning behind the original guniting program? What sort of areas were covered with the ¾ in. gunite? Presumably all the seams and faults in the tunnel had been mapped at the time of the original excavation. Why was the decision taken not to cover these seams with gunite? Were any erosion estimates made?

The decision to line a tunnel or not in such circumstances is a difficult one and the authors are to be commended on their excellent presentation of the Kemano tunnel problems. The paper contributes greatly to the knowledge of how to proteet erodable seams encountered in otherwise sound rock, and will greatly increase the confidence of engineers in their ability to deal with them safely without lining the tunnel.

Discussion by
W. Harland,
Caseco Consultants Ltd.

In this paper the authors have provided a careful description of an operation which was followed with great interest and curiosity by the engineering profession in Canada. Interest was heightened by the dangers involved and by the signifieance of the outcome. Seldom do we see an instance when the operation of an important industry and the existence of a large community are so singularly affected by an engineering problem. The authors have concentrated on the engineering aspects of the operation but the statistics quoted give a hint of the logistic problems. No doubt the problems of moving men and materials in and out of the tunnel could properly be the subject of another paper.

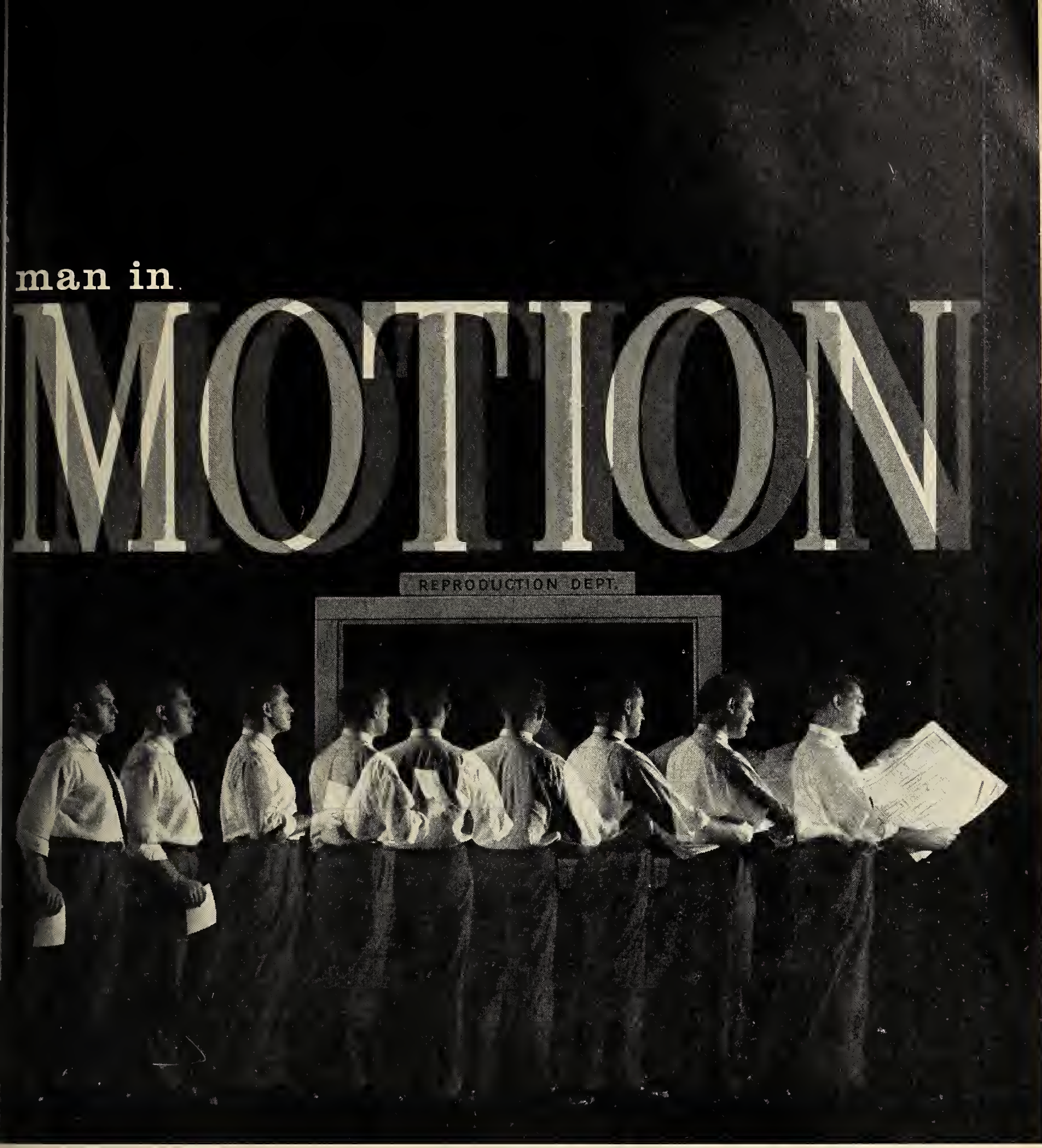
Perhaps the most interesting point brought to our attention by the authors is the fact that even in view of the extensive repairs required in 1961, the original deeision to use an unlined tunnel appears to have been justified. This was a bold deeision in view of the trend to extra-conservative design. While one can find no fault with the principle of conservative design in general there are times when the construction cost of certain features of design could be carefully weighed against the capitalized cost of a planned maintenance and repair program. The economie comparison which the authors make between the cost of lining in 1954 and the cost of the repairs in 1961 is particularly noteworthy.

Planned and scheduled repair programs are often not envisaged for large civil engineering structures. In some eases this requires a new outlook involving the aeceptance of the principle of future repair. Sometimes, as in the case dealt with by the authors, this requires one single repair operation and at other times it requires repairs on a scheduled basis.

Maintenance is, after all, a product of our recently technological advance — quite unknown for example to the pharoahs of Egypt. The authors have proven that we have indeed advanced.

Discussion by
F. L. Lawton, M.E.I.C.,
Vice-President and Chief Engineer,
Power Department
Aluminium Laboratories Limited
and
M. D. Lester, M.E.I.C.,
Senior Engineer, Power Department,
Aluminium Laboratories Limited

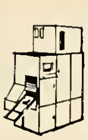
(Continued on page 72)



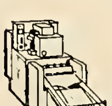
an engineer that doesn't wait for working prints!

y? Because his firm, like hundreds of other leading industrial comnies, has converted its print reproduction systems to *xerography,* the st economical (and versatile) copying process in the business! Xerogra lets sharp, inexpensive prints in varying sizes get to every department *minutes* . . . on dry, ordinary, ready-to-use paper. There's no capital estment, either. Xerographic copying equipment is immediately availe at modest monthly rentals. *Find out how it can go to work for you!* ite Xerox of Canada Limited, Dept. 27, 20 Mobile Drive, Toronto 16.

MODEL 1218 copying equipment for sharp, inexpensive paper masters from original drawings of A to D size.



COPYFLO® Continuous Printers* for automatic high volume reproduction from originals or roll microfilm.

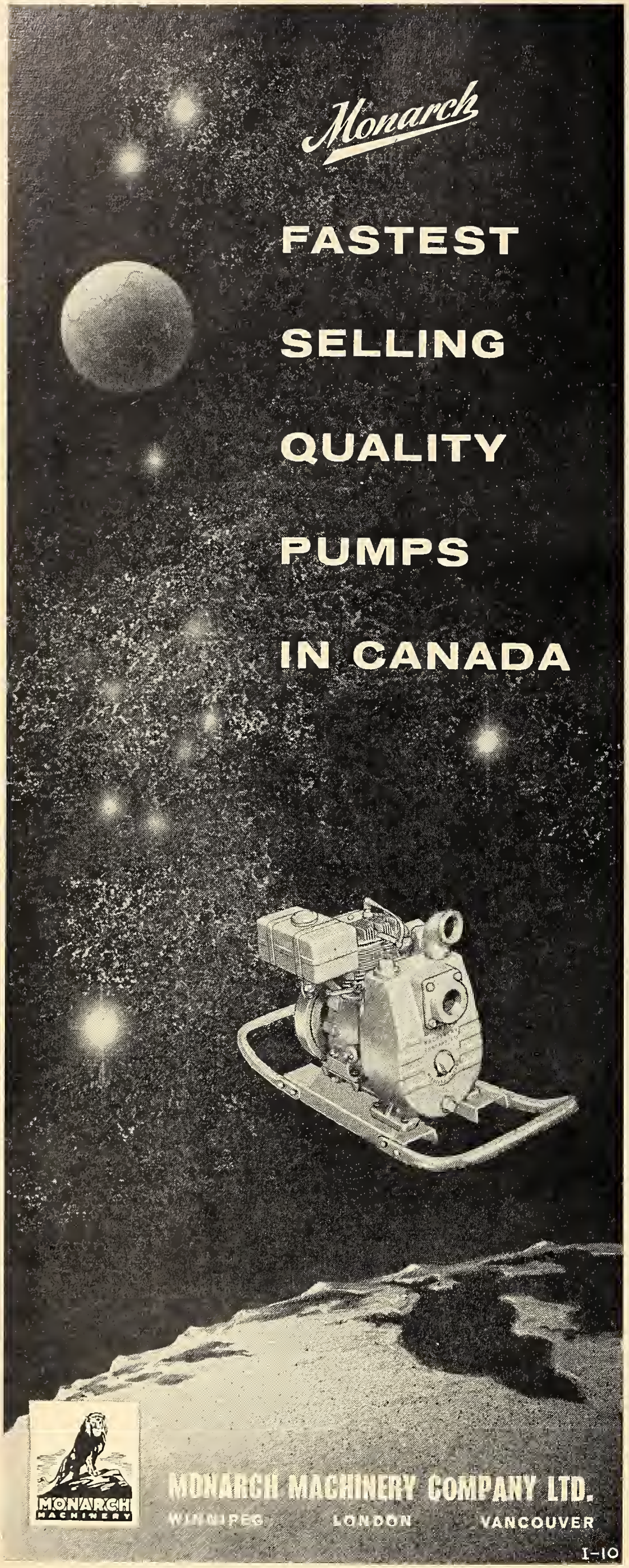


COPYFLO 24C* for fully automatic high speed reproduction from roll or card-mounted microfilm.

1824® PRINTERS reproduce from jacketed microfilm, roll microfilm, or card-mounted microfilm.

*Prints on ordinary paper, vellum or paper masters at rate of 20' per min.

XEROX
OF CANADA LIMITED



• Discussion

(Continued from page 70)

Too infrequently does the engineering profession get the opportunity to have a close look at an undesirable and unanticipated mishap in the life of an important structure. While modern methods and practice have made such occurrences increasingly rare, reports of those that do occur are rarer still.

When the structure in question is as notable a project as the Kemano tunnel, a description such as the authors have presented takes on added significance. As one of the world's major power tunnels, with both lined and unlined sections, its behaviour and performance are of great interest to all those concerned with conveying large volumes of water over an appreciable distance.

Perhaps the first questions to logically spring from the paper are these: —

1. Under what conditions will the amount of material falling from a tunnel periphery be excessive, i.e., greater than an acceptable amount of minor spalling and ravelling?

2. What measures can reasonably be taken to recognize and control these conditions?

The paper describes some particular geological circumstances which, over the years of operation, resulted in numerous small rockfalls and one surprisingly large one. The source of these failures has been shown to be in the nature of the material comprising the fault zones. When these zones were filled solely with the soft, clayey substance known as gouge or selvage, no deterioration occurred. Where the gouge was in contact with calcite, however, gradual dissolution of the latter permitted increased circulation of water in the fault zone and led to a continuing erosion process. Similarly, some of the fault zones included mylonite, which is a slate-like, cleavable substance produced by thrust faulting. Here, even in the absence of calcite, differential erosion between the mylonite and gouge tended to make each material unstable and more vulnerable to continuous erosion. The larger rockfalls were initiated when the above processes, occurring in contiguous zones, resulted in the loosening and releasing of substantial blocks of sound rock. This, of course, created turbulent hydraulic conditions at the site and presumably hastened the removal of additional vulnerable material.

Those sections of the tunnel which were concrete lined suffered no damage. There was no evidence whatever

of the deterioration sometimes noted when the alkalis in cement react with silicas or carbonates in the aggregate.

While most of the unreinforced gunite sections remained intact, the fact that numerous rockfalls did occur in this type of section suggests that unreinforced gunite cannot always be depended upon to permanently shield erodible seams from water action. In this connection it is interesting to note that the evidence suggests that, at all damaged sites, the failures were apparently initiated early in the history of the tunnel. The authors' proposition that all the significant weaknesses have already been "found" has an analogy in the proverbial "bugs" which turn up during the breaking-in period of new machinery or equipment.

As to what lessons are to be learned from the Kemano tunnel experience, one must avoid drawing conclusions based on hindsight alone. Certainly, any tunnel should be subjected to continuous and close geological appraisal by qualified specialists during the course of construction, especially when all or part of the tunnel is intended to remain unlined. Where lining or gunite is deemed necessary, careful preparation, placing and reinforcing are obviously important. Where preliminary geological investigation and economic analysis lead to an unlined tunnel design and construction is accompanied by the aforementioned measures, a subsequent mishap does not invalidate the original engineering decision. Indeed, even as severe a repair operation as described by the authors is shown to be less expensive than the incremental cost of the concrete lining that would have had to be placed originally to guarantee that a rockfall would not occur.

One of the most interesting aspects of the Kemano story has been the variety of hydraulics problems which were involved in both the operational and repair phases of the tunnel. A brief note on some of these may serve to supplement the authors' remarks.

Soon after the completion of the development, when it appeared that head losses were in excess of the design values, it was felt necessary to confirm the latter by methods based on the actual finished sections. One such calculation was carried out on the basis of Manning's $n = 0.014$ for the lined sections and $n = 0.038$ for the unlined or gunited sections. Another approach was to compute the losses in the unlined section by the method developed by Rahm in Sweden, whereby the variation in cross-

(*Continued on page 74*)

Discussion

(Continued from page 73)

sectional area along the tunnel axis is held to govern the effective relative roughness. In all cases, the estimated head losses for the tunnel were found to agree within 10% of the original design value.

During the long period when the so-called flushing runs were reducing excess head losses to an acceptable level, it was difficult to ascertain the exact nature of the mechanism causing the difficulty. While it was known that most of the excess was occurring in the five mile long downstream half of the tunnel, the absence of intermediate piezometer stations precluded the possibility of localizing the trouble, if indeed it was a local problem. This, incidentally, argues positively for the inclusion, in tunnel or conduit design, of a greater number of points at which pressure can be measured. By more closely pinpointing the location of any trouble, evaluation and planning of repairs are obviously facilitated.

The rather sudden increase in head loss in 1959 and the erratic pattern of the surge chamber water level following an accidental load rejection in 1960 were the first tangible clues to the nature of the condition causing the excess head losses. The character and location of the rockfall were then successfully estimated by means of the salt-velocity and water-hammer tests described in the paper.

To control the drainage of the 25 million cu. ft. of water in the tunnel with the power station continuing to generate until near the end of the operation was another phase which required careful co-ordination of intake gate closure and of load-shedding increments. Similarly, the refilling operation, after repairs had been completed, was carefully programmed to avoid undue pressure changes in the supply system.

With regard to the rockfalls experienced over the years in the Kemano tunnel, the role played by the inevitable transient pressure waves which accompany sudden load changes is difficult to evaluate. Certainly, the unlined sections have been subjected to rather steep wave fronts from time to time, due to accidental rejections. Common prudence would dictate that scheduled load changes be as gradual as possible, a policy rigorously enforced at Kemano.

Discussion by
D. H. MacDonald, M.E.I.C.,
Director,
H. G. Acres & Company Limited,
Niagara Falls, Ont.
and
P. G. Morris,
Head, Geology Department,
H. G. Acres & Company, Limited,
Niagara Falls, Ont.

In the broad field of civil engineering there are few, if any, branches which contain as much art and as little science as does tunnelling. This does not for a minute imply that a scientific approach to tunnelling is not possible or justified; on the contrary it only emphasizes the importance of experience and judgment in such matters. The progress of tunnel engineering is certainly measured in terms of experience, and adequately-documented case histories of tunnels are invaluable to continued progress by all engineers in this field. For making available this most interesting performance record of the Kemano Tunnel the authors are due the thanks of the profession.

To use the words of the authors, "The cost of the 1961 repair and maintenance work was unexpected

and disappointing." In any unlined or partially-lined tunnel such as Kemano some minor rock falls are to be expected, but these are usually of no serious consequence and are acceptable. Large rock falls, such as the one at Kemano, if anticipated, are guarded against in the initial construction. The fact that such a large and unexpected rock fall did occur at Kemano can not and should not be interpreted as a failure of the tunnel, as the authors rightly point out that the choice of the unlined tunnel is still economically justified even when including the cost of the recent repairs. Moreover, the Kemano experience should not be used as a general condemnation of unlined tunnels.

The ultimate choice between a lined and an unlined tunnel is largely one of economics, based upon a thorough consideration of all the physical, financial, and operational factors. Where rock conditions permit the lining to be eliminated and economic factors do not recommend one, there is little doubt as to the advisability of an unlined tunnel. Implied in the choice of an unlined tunnel, however, is the need to take precautions in the form of surface treatment of the rock in selected areas of doubtful stability, and the possibility that some minor remedial work may be required as a future maintenance operation.

This approach was adopted in the design of the low-pressure, tailrace discharge tunnel of the Chute-des-Passes Power Development [1] in Northern Quebec, which was completed in 1959. This unlined tunnel is 48 ft. in diameter and nearly two miles long. It passes through rocks of the Canadian Shield which are predominantly of gneissic and granitic types; the quality of rock is generally very good but the tunnel was intersected by several minor faults and shear zones and numerous joints. For economic reasons, principally associated with surge problems, the tunnel was left unlined. Complete geological mapping was done during excavation, and on the basis of this a small number of locations were selected for treatment during construction. The treatment was somewhat varied, but usually consisted of either pattern rock bolting or of reinforced gunite, similar to that described in this paper, or of a combination of rock bolts and gunite.

Recently, the senior writer had the interesting experience of visiting this tunnel during its first unwatering, in company with two of the authors. The tunnel had been in operation

(Continued on page 80)

Sixteenth

Soil Mechanics Conference

and

Zone "A" Technical Meeting

September 12-14, 1962.

Edmonton, Alta.

Wednesday, September 12

REGISTRATION:

OPENING REMARKS: Dr. R. M. Hardy, Conference Chairman and C. B. Crawford, National Research Council

TECHNICAL SESSION I: (MORNING) Volume Change Characteristics of Highly Plastic Soils — C. B. Crawford, Chairman

1. On the Swelling and Shrinkage of Several Highly Plastic Clays
J. J. Hamilton, N.R.C.
2. Heave of Spillways on Clay Shales
R. Peterson & N. Peters, P.F.R.A.
3. Practical Experience with Highly Swelling Soil Types
R. M. Hardy, (R. M. Hardy & Assoc.) and A. O. Dyregrov, (Underwood, McLellan & Assoc.)

TECHNICAL SESSION II: (AFTERNOON) Physico-Chemical Aspects of Soils G. B. McRostie, Chairman

4. Physico-Chemical Phenomena in Soil Materials
Dr. S. Pawluk, University of Alberta
5. Measurements of Shear Strength, Plasticity and Water Retention of Clays Related to Interparticle Forces
Dr. B. P. Warkentin, MacDonald College, Montreal
6. Shear Strength of Remoulded, Normally Consolidated Homionic Clay
Professor S. Thomson, University of Alberta
7. Engineering Properties of Illitic Clays Related to Fabric and Pore Water Composition
Dr. R. M. Quigley, Geocon Co. Ltd.

BUSINESS SESSION: Soil Mechanics Subcommittee of Associate Committees of Soil and Snow Mechanics, N.R.C.
Geotechnical Division of the Committee on Technical Operations, E.I.C.

EVENING: Research Seminar — Research on the Physico-Chemical Aspects of Soils as Related to their Engineering Properties
Professor David Townsend, Chairman

Thursday, September 13

(Combined Soil Mechanics Conference and Zone "A", E.I.C.)

REGISTRATION:

OPENING REMARKS: Dr. R. M. Hardy, Conference Chairman; F. M. Cazalet, Vice-President, E.I.C.; Professor J. B. Mantle, Vice-President, E.I.C.; Dean G. W. Govier, University of Alberta

TECHNICAL SESSION III: (MORNING) Professor J. Longworth, University of Alberta, Chairman

8. Surficial Deposits in Alberta
Dr. C. P. Gravenor and Dr. L. A. Bayrock, Research Council of Alberta
9. A paper on the Pine Point Railway with emphasis on the Soil Conditions and Problems
F. L. Peckover, C.N.R.
10. Preliminary Soil Mechanics Aspects of the Red River Floodways
J. Mishtak, Soil Mechs. Eng., Water Control & Conservation Branch, Manitoba Dept. of Agriculture

INFORMAL LUNCHEON: Northern Alberta Jubilee Auditorium

TECHNICAL SESSION IV: C. F. Ripley, Chairman

11. Foundation Treatment and Construction of 16 Miles of Dyke at Manitoba Hydro's Grand Rapids Project
A. Koropatnick, W. S. Isom & J. R. Rettie, Manitoba Hydro

DINNER: Arranged by the Edmonton Branch, E.I.C., MacDonald Hotel

Friday, September 14

(Engineering Institute of Canada Zone "A" Technical Meeting)

TECHNICAL SESSION V: (MORNING) J. C. Dale, Chairman

Design of Pipe Lines to Minimize Brittle Failure
V. P. Milo, Shell Oil Co.

The Alberta to California Pipeline System
D. P. Smith and/or W. L. Kennedy, Canadian Bechtel Ltd.

Energy Interchange and a National Grid
D. Cass-Beggs, Sask. Power Corp.

The Alberta Electric Power Situation
G. A. Gaherty, Montreal Engineering Co. Ltd.

INFORMAL LUNCHEON: Northern Alberta Jubilee Auditorium

Official Opening of the New Wing, Engineering Building, University of Alberta

TECHNICAL SESSION VI: (AFTERNOON) Dr. R. W. McManus, Chairman

Oil and Gas Reserves in Western Canada
J. G. Stabback & R. D. Craig, Alta. Oil & Gas Conservation Board

The Remote Control of a Gas Field
J. H. Schwartz, Timewell Controls Ltd.

Tours of Engineering Laboratories, University Campus

DU PONT
CANADA

As a result of expanding activities, we have immediate openings for Engineers of the following disciplines at the locations shown:

POSITIONS	DISCIPLINES	LOCATION
Development Engineers	Chemical & Mechanical Engineering	Research Centre, Kingston, Ont. Sarnia, Ont.
Industrial Engineers	Industrial Engineering, Engineering and Business or equivalent experience	Montreal, P.Q. Kingston, Ont.
Design Engineers	Chemical, Mechanical or Civil Engineering, Engineering Physics	Maitland, Ont. Kingston, Ont. Montreal, P.Q.
Process Engineers	Chemical Engineering	Ajax, Ont. Kingston and Maitland, Ont.
Research Engineers	Chemical Engineering at Ph.D. level	Research Centre, Kingston, Ont.

Candidates should be graduates of recognized universities with up to five years industrial experience.

Please reply, briefly stating education, experience, age, and position and location preferences if any, to:

Personnel Division
DU PONT OF CANADA LIMITED
P.O. Box 660 Montreal, Quebec

IRON ORE COMPANY OF CANADA

QUEBEC NORTH SHORE & LABRADOR RAILWAY COMPANY

offer jobs for qualified and experienced ENGINEERS AND FOREMEN

In Research — for laboratory and pilot plant: to conduct research in the fields of iron ore beneficiation and agglomeration.

In Planning — for design of open pit mines, roads and mine railroads; for ore calculations, stripping estimates, and geological interpretation.

In Production — to supervise open pit mining operations.

In Maintenance and Construction — for our repair and service shops and our heavy schedule of construction, or, for special projects in both the electrical and mechanical fields.

In Railroading — for railway construction and maintenance; Engineers being familiar with all phases of line survey, grade construction and structures, and Foremen with railway maintenance and extra gang supervision.

In Communications — for engineering in microwave and carrier systems as applied to multi telephone and teletype circuits; VHF radio, telephone links, mobile radio and advanced industrial electronics.

SALARY AND OTHER BENEFITS — Depending on experience. Group Insurance Hospitalization; Pension Plan. Vacation — from 2 weeks after 1 year to 4 weeks after 3 years. Housing conditions vary from staffhouses to individual homes depending on location of work.

FURTHER INFORMATION MAY BE OBTAINED FROM:

Personnel Department
Iron Ore Company of Canada
Office 306
810 Cote de Liesse Road
Montreal, P.Q.

SITUATIONS VACANT

CHEMICAL

CHEMIST — At least 5 years' experience with vinyl resins and plastisol formulations.

CHEMICAL ENGINEER — Preferably one who has had experience in operating high temperature vinyl coating ovens. Top salaries for the above positions. Excellent opportunity for advancement. Fringe benefits. Apply, with full references, to File No. 240-V.

CHEMICAL ENGINEER. A well known industrial firm with plants throughout the world requires the services of a Chemical Engineer at its factory in Drummondville, Que. This position involves the development of new process and products in order to maintain an improved company leadership in its field; the establishment and operation of a comprehensive Quality Control System applicable to raw material and goods produced. Applicant must be bilingual and have preferably two to four years' experience in pigments, plastics, or inks. Salary will be commensurate with experience and employee will profit from attractive Company benefits and personnel program. All replies will be held in strictest confidence. Send complete resume of personal history and qualifications to: Eagle Pencil Company, Drummondville, Que. Attention: Mr. J. Moreau, P.Eng.

MECHANICAL ENGINEER
BUILDING MAINTENANCE

$9,120 — $10,300

The Airport and Property Management Division of the Department of Transport at Ottawa requires the services of a professionally qualified Engineer with preventive maintenance experience to develop standards for the operation and maintenance of heating, ventilating, air conditioning and refrigeration systems and elevators, escalators and baggage handling equipment.

For further details and application forms write to the CIVIL SERVICE COMMISSION OF CANADA, OTTAWA, requesting Information Circular 62-1207.

CIVIL

GRADUATE CIVIL ENGINEER — age 30 to 35, with estimating and field experience with heavy engineering construction contractor. Applicants who are interested in working with expanding, well established Contractor are asked to send their applications, stating qualifications, full particulars and languages, to P.O. Box 23, Postal Station "R", Toronto 17, Ontario.

CIVIL ENGINEER — A national association with headquarters in Ottawa requires an engineer interested in all aspects of highway research and development. Candidates should have a special aptitude for the writing of reports and technical correspondence. Salary — $5,000 to $6,000. Applications or enquiries for further information. File No. 234-V.

CIVIL ENGINEER — Challenging opportunity for young civil engineer with growing company in the field of municipal construction. Location Western Ontario. Reply giving complete references, experience, age, and salary expected, to File No. 233-V.

CITY OF MOOSE JAW requires CITY ENGINEER. Duties: To supervise all phases of Municipal Engineering, including the overall planning, design, construction and maintenance of engineering works for the City of Moose Jaw. Qualifications: Applicants must be registered or eligible for registration with the Association of Professional Engineers of Saskatchewan. Should have a minimum of three to five years experience related to the field of municipal engineering or, alternatively, post-graduate training in Engineering. Applicants should give full information as to age, marital status, training, experience, references and date services will be available. Salary will be commensurate with qualifications and experience. Applications should be submitted to: The Personnel Director, City Hall, Moose Jaw, Saskatchewan.

MECHANICAL

MAINTENANCE ENGINEER — Graduate Mechanical Engineer or equivalent with a minimum of five years experience in the maintenance of heavy equipment in a mine, mill and/or smelter. Location: Falconbridge, Ontario. Excellent employee benefits. Apply in writing, giving full particulars of qualifications, experience and age to File No. 236-V.

DESIGN ENGINEER — With experience in pressure vessel and steel platework design. Should be familiar with ASME and API codes. This is a permanent position with full benefits. Reply in confidence with all details to our Chief Engineer, Toronto Iron Works, 629 Eastern Ave., Toronto, Ontario.

MISCELLANEOUS

ENGINEER-PLANNER — Staff Position, City Planning Division, Morris Knowles Inc. $7200. Write: Personnel, Morris Knowles Inc., 316 Drake Bldg., Easton, Pa., U.S.A.

TORONTO — Well established progressive Toronto Company, operating two plants in the process industry and engaged in a major modernization program, requires a graduate engineer, preferably electrical, although he will be involved in a wide variety of projects. Candidates for this position should have 3-5 years' experience in the plant engineering areas. The position offers a young engineer a challenging opportunity, for initiative will earn him considerable freedom and scope within the function. Apply in confidence, giving full particulars to: File No. 232-V.

• Discussion

(Continued from page 75)

about two years, and with the exception of some loose rock bolts it looked virtually the same as it did when last seen in 1959. At no point throughout its entire length could one say that any sizable piece of rock had fallen. All of the gunite appeared to be in very good condition, and the amount of leakage from the rock into the tunnel appeared to be negligible. The only change of note was that a considerable number of the rock bolts had come loose and were hanging from the roof and walls. On the Chute-des-Passes project it can, therefore, be said that an unlined low-pressure tunnel of large diameter has been highly successful.

To return to the Kemano tunnel, we believe that everyone will be impressed by the ingenuity of the hydraulic testing which was used to evaluate and locate the source of trouble before unwatering. It would be of considerable interest if the authors could indicate the extent of geological data that were available from the original construction period, and the extent to which they were helpful in the pre-unwatering studies and the post-unwatering inspection.

The geological description of the mechanism of failure in the fault and the shear zones is of particular interest since it may hold the key to the successful application of this experience to other tunnel work. If, as is suggested, the solubility of the calcite veins is one of the chief causes of instability, and if much of the rock fall, particularly in the Tahtsa-Horetzhy section, occurred soon after tunnel filling, one would conclude that the water might be highly acid. Could the authors state what the pH of the water is, and would they care to comment on the possibility that the loosening of rock might be contributed to by mechanical vibration as much as by solution of the calcite?

The ingenuity with which the repairs were effected at the location of the major fall illustrate the reason why this difficult operation was completed successfully, and it gives good reason to believe, as the authors do, that little more trouble will be experienced with this tunnel.

1. Matthias, F. T., Travers, F. J., and Duncan, J. W. L., (1960). "Planning and Construction of Chute-des-Passes Hydro-Electric Power Project", Engineering Journal, V.43, N.1, pp 38-51.

Discussion by
R. W. Spencer,
Assistant Vice-President,
Southern California Edison Company,
Los Angeles.

The writer found the paper to be of unusual interest for two reasons; 1) because it describes an extremely difficult repair performed in an economical and efficient manner; and 2) because it adds to a limited fund of knowledge as to what happens to tunnels after they are put into service. Most long tunnels have several papers written about them describing their design and driving methods. Less frequently there are papers on the geology and its influence on the design. What happens after the tunnel is put in service is usually left to a few news-notes in an obscure newspaper or word-of-mouth stories. The paper on Kemano will have value to anyone having to do with the design and construction of tunnels.

The writer is in full accord with the conclusions reached, particularly

EIC CERTIFICATE OF ADVERTISING MERIT

The Algoma Steel Corporation Limited knows a good thing when it sees one! A dramatic, full colour, bleed photo of the new wide flange beams now being produced in their Canadian mill, still white hot, captured the Journal's monthly award for December, 1961, and March, 1962. Now the same scene, photographed from a different angle, wins the Certificate of Advertising Merit again, as the best advertisement in our May issue.

In this version, the illustration occupies slightly over 80% of the page, compared to about 60% in the previous version. Heading which previously introduced the product only—"Canada's first wide flange beams now produced by Algoma steel" —now adds benefits—the new version reading, "Wide flange beams from Algoma add new scope and versatility to structural steel".

The advertising of Algoma Steel is under the direction of Mr. L. Brown, Administrative Assistant to the President. The winning advertisement was produced by the Toronto office of Cockfield, Brown & Company Limited, Mr. F. D. Adams, Account Executive.

Each month a different panel of fifty Journal readers from across Canada is asked to nominate an award-winning ad of their choice from the viewpoints of ACCURACY–INFORMATION–ATTRACTION.

---

the economy and practicability of coating thin seams of poor or decomposed rock with gunite. In this connection, the writer would like to comment briefly on the experience of the Southern California Edison Company with 42 miles of tunnels on the Big Creek Project in the Sierra Nevada Mountains. The tunnels are mostly in relatively sound granodiorite. The size varies from 7 ft. x 7 ft. to 24 ft. x 24 ft. and the percentage of concrete lining varies from 1.6% to 15.3%, including pipe encasement near the portals. The age of the bores varies from 5 to 50 years. Like the Kemano tunnel, the Sierra Nevada tunnels are lined only where support was necessary to prevent collapse. It was never found economical to line a tunnel to reduce friction.

Substantial repairs have been necessary in only about five cases. In two cases after 20 years of service the original horseshoe-shape lining was found to be cracked from squeezing ground under a cover of a thousand feet or more and repairs were made by forming a circular section of heavily reinforced gunite inside the conventional horseshoe lining. Since the sections were short, 20 ft. and 235 ft. respectively, the reduction in size could be tolerated with only negligible hydraulic losses.

In one case in the 13 mile Florence Lake Tunnel, a rock fall of about 200 cu. yd. occurred as a result of water eroding thin, parallel seams in the tunnel roof, 2 ft. to 4 ft. apart and ½ to 2 in. thick, which permitted large blocks to fall in a manner similar to some of the Kemano failures. This one group of seams was omitted from the guniting program which worked effectively for over a hundred other seams scattered along a 13 mile length of tunnel. Repairs were made by filling the fissure with a slab of concrete 2 to 4 ft. thick and 115 ft. long. The rock fall in this case was a progressive action over a period of 20 years. All other rock falls have been less than 10 cu. yds. and have required no repairs.

In one 12 ft. diameter tunnel, constructed in 1912, there have been two cases of trouble as a result of insufficient top and side cover on a very steeply sloping mountainside. In the first case, washouts on a series of joints several feet wide required repairs after 20, and again after 25 years of service. In the second case, leakage developed along a deep-seated regional joint system where decomposition had occurred in seams with a thickness from ½ in. to possibly 2 ft. Gradual increasing leakage along these joints eroded the material and permitted hydro-static pressures to develop in joints roughly parallel to the mountainside. These pressures caused shifting of successive layers of rock and threatened to work back to the tunnel itself. Repairs were made by placing 800 ft. of free standing pipe in the tunnel and providing for drainage of the space around the pipe. The case is noteworthy because the first signs of leakage and sliding occurred after 43 years of service. Repairs were finally necessary after 50 years of service.

In summary, the experience with decomposed granite seams in the Sierra Nevada tunnels has been quite similar to that at Kemano. If such seams are exposed to flowing water in pressure tunnels, the soft filling will wash out, and if there are several parallel seams close together, a rock-fall will develop, the extent depending on the number and spacing of the seams. However, even a thin coating of gunite has been successful in preventing erosion and consequent rock-falls, for periods up to 30 years with indications of indefinite life. It is apparent that a small expenditure of money for guniting such seams is well justified.

One last precaution should be pointed out: Thin, decomposed seams are difficult to find in a dusty or dirt-coated tunnel during construction. Before treatment of such seams is started, the entire tunnel interior should be thoroughly washed with water, preferably using a nozzle of fire-hose size. Such washing will show up the erodable seams.

Discussion by
H. E. Dann,
Associate Commissioner,
Snowy Mountains Hydro-Electric Authority, Australia.

The paper has been studied with great interest in the Snowy Mountains Hydro-electric Authority.

The Authority has, during the past 10 years, constructed approximately 49 miles of tunnels, 37 miles of which are nominally unlined, and it has also currently under construction a further 32 miles of tunnels, 25 miles of which are to be essentially unlined.

The authors are to be congratulated on the excellent presentation of the paper and the frank disclosure of the nature and extent of the rock falls encountered and the repair techniques employed.

The information that the major rock fall, as well as many other falls, were initiated by the deterioration in water of a seam of crushed rock and clay only ⅛ in. to 2 in. wide is particularly significant, since it indicates the need for meticulous inspection of the rock when determining the final treatment of an unlined tunnel. Seams of this size can easily pass undetected especially in large tunnels where roof and walls are coated with rock dust from blasting.

Some statistics on the Snowy Mountains Authority's unlined tunnels now in service are as follows:

(Continued on next page)

Tunnel	Size	Length Miles	Type of Rock	Concrete Lining per cent	Date in Service	Date of Inspection
Guthega	19 ft. Horseshoe	2.9	Granite	18.6	Feb. '55	June '56 March '58
Eucumbene-Tumut	23 ft. dia. Circular	13.8	40% granite and remainder highly folded sedimentary rocks, chiefly slatey shale, indurated siltstone and quartzite.	29.1	July '59	Dec. '61
Tooma-Tumut	12 ft. Horseshoe	9.0	Granite	21.4	May '61	—
Murrum-bidgee Eucumbene	11 ft. Horseshoe	10.4	90% highly folded sedimentary rocks, chiefly slatey shale and quartzite.	17.7	Feb. '61	May '62

Since the construction of the Eucumbene-Tumut Tunnel extensive development of the use of grouted rock bolts has taken place in the Authority. These bolts used as a prime method of permanent support, together with the use of gunite for the protection of doubtful seams, has enabled a significant reduction to be made in those parts of the later tunnels which otherwise would have required concrete lining.

In the Eucumbene-Tumut Tunnel gunite was not specified as a method of treating the rock but since the construction of that tunnel it has been specified for all the Authority's unlined tunnels.

As indicated above, these tunnels (except Tooma-Tumut Tunnel) have been inspected after several years in service. The tunnels have been in very good condition with only occasional isolated small rock falls. These falls have ranged from ½ cu. yd. to 5 cu. yd. and the largest experienced to date was in the Eucumbene-Tumut Tunnel where a cavity of approximately 30 cu. yd. was formed by the progressive disintegration of a basalt dike of unusual composition. This dike was vertical, approximately 2 ft. to 3 ft. wide, with a strike across the tunnel at right angles. The cavity formed by the disintegration and fall out of the dike extended in some places to 18 ft. above the roof. This cavity was filled with concrete.

Murrumbidgee-Eucumbene Tunnel was inspected recently and the many gunited sections were found to be in excellent condition. The Authority's experience to date supports the authors' confidence in "properly applied gunite adequately reinforced and anchored" as a simple, effective and permanent means of treatment of seams in unlined tunnels.

The practice on all tunnels constructed by the Authority has been to carry out a complete geological logging as the excavation progresses. These measures appear to be justified in ensuring that steps are taken during construction to provide ultimate structural soundness.

Discussion by
Karl Terzaghi

The performance records of the numerous pressure tunnels of the Pacific Gas and Electric Co. and of the Southern California Edison Co. demonstrate very impressively that it would be a waste of capital to line those sections of pressure tunnels through granite which do not require any support during construction. Even the cost of repairing the Kemano tunnel was moderate compared with that of lining the entire tunnel. Yet rockfalls are a nuisance and may interfere temporarily with the operation of a powerplant. Therefore, the means for preventing the rockfalls described in the paper are a topic of outstanding importance. The following paragraphs contain a few supplementary remarks concerning this topic.

The foremost requirement for preventing rockfalls consists in sealing all those seams which may be scoured out while the tunnel is in operation. Satisfactory procedures for accomplishing this purpose are described in the paper under the heading "Seams" and illustrated by Fig. 4. The application of the seals and the type of seal can be prescribed in the specifications. However the seams which ought to be sealed must be selected in the tunnel, in the absence of the author of the specifications. The resident engineer has many obligations other than supervising the sealing of seams. The difficulties involved in locating and sealing the seams depend to a considerable extent on the degree to which the rock was damaged by blasting. If the tunnel is wet the application of the seals is quite a delicate operation and the details of the procedure must be adapted to the local rock surface topography which changes from place to place. On account of the great variety of conditions which may be encountered, the processes of selecting the seams and sealing them assumes the character of rock-dentistry the success of which depends to a large extent on the qualifications of the foremen and the workmen. Since there are no schools of rock dentistry and no licensed professional rock dentists it is rather difficult to discriminate between competent and incompetent ones before they are in action. Rock defects like the one responsible for the big rock fall in the Kemano tunnel would not escape the attention of a competent geologist, but he too is only an expert in geology; the degree of competency in the field of rock dentistry depends entirely on what he happened to learn about it on other tunnel jobs. If a tunnel is located in a foreign country none of the workmen may ever have heard about sealing operations and very few tunnel jobs are important enough to justify adding a resident geologist to the field force.

Considering the decisive influence of these factors on the success of the sealing operations the writer would appreciate the authors' comments on this aspect of the subject of their paper, and to express their opinion concerning the possibilities for minimizing the consequences of the fact that the vital details of the sealing operations are far beyond the scope of the plans and specifications.

1. **"Major Underground Excavation of the Pacific Gas and Electric Company" by J. B. Cooke, Second Rand Symposium on Underground Installations, June 1958, Rand, San Diego, Cal.**

Discussion by
C. P. Dunn,
Consulting Engineer,
Atherton, Calif.

Tunnels for the conveyance of water are an important feature of the general economic scheme of things, and the cost of concrete lining is a very large part of tunnel costs. The designer and the construction engineer are continually faced with the necessity to make decisions in regard to the extent to which lining of rock tunnels can be omitted as an improvement of the economics of a project as a whole. He needs the answer to the question "If we omit the lining in these places where we are considering omission, will the saving in fixed charges be greater or less than the possible added cost of maintenance and operation?" The question is obviously not quite that simple. There are many things which affect the answer, such as availability or non-availability of the tunnel for reasonably frequent shut-down for inspection and maintenance. The Aluminum Company of Canada Ltd. took a "calculated risk" in omitting the lining of certain portions of the Kemano

tunnel. This action was proper, and is confirmed by the facts now available. There is no "hindsight" change of opinion.

The value of the paper under discussion is that it adds to the general knowledge of the subject of design of tunnels for the conveyance of water, and helps to establish the fact that under certain economic and physical conditions lining should be omitted, and points the way toward "what to look out for and what to do about it".

During the construction of Kemano tunnel, certain areas were covered with gunite quickly, a part of the reason being (a) safety of construction personnel and (b) speed of construction. These requirements were a strong influence toward immediate application of gunite. Obviously there was also a strong contrary influence toward leaving the rock bare for a longer period for more thorough inspection and repair of "faults". Such conflicting requirements are an inherent part of construction procedure.

The writer adds the following thoughts, which are not in contradiction to anything in the paper, but are expressed in a different way.

The crust of the earth is imperfect as a structural material. It is not absolutely fixed in position. Geological movements of the rock cause imperfections called "faults." Faults are "cracks" which may be open or may be filled with "gouge" (finely ground rock debris) or may be filled with matter carried by ground water either mechanically or in solution. If rock masses move relative to each other, there is shearing and grinding and "gouge" is produced. If rock masses move directly away from each other, a crack opens up, maybe minute in dimension or maybe several inches or feet across, and eventually the crack gets filled up with some material different from the adjacent rock masses.

Both of the above types of fault must be contemplated by a tunnel designer.

The earth's crust is "folded" or "wrinkled" geologically in contortions of both small and large dimension. The tunnel designer must think in terms of folds several miles across, and must try to find out whether his tunnel is passing through the compression side or the tension side of a wrinkle. If he is on the tension side (as part of Kemano must be), the tunnel ground is difficult because the rock fragments tend to separate from each other, to "fall apart". If he is on the compression side of a fold, the rock fragments are held together by the initial stress, and it is easier to dig a tunnel through them.

In the paper, there is mention of "erosion" of material from faults, and the need for protection against erosion. The writer agrees with this, and points out that there are several ways erosion can occur — (a) by the body of water being carried through the tunnel flowing past or across a fault zone. This velocity is not very great, and this type of erosion is slow; (b) by ground water, at pressures higher than the hydraulic gradient of the tunnel; carrying material out of the cracks and into the tunnel, and (c) where there is no continuously high ground water pressure, water will move in and out of cracks because of normal variations in the hydraulic gradient.

Discussion by
Franklin T. Matthias, M.E.I.C.,

I consider this paper a really important contribution to engineering

(Continued on next page)

• Discussion

(Continued from page 83)

literature. It helps to relieve an existing deficiency of information on head losses in large tunnels under various conditions of flow. The opportunity to analyze effects of varying conditions of partial blockage in large tunnels is not common and I want to congratulate Mr. Madill for making the most of this opportunity to collect and analyze the maximum of information available on these phenomena.

Further, this paper illustrates a degree of careful, detailed planning of the extremely demanding job of construction repair operation that is not common in the construction industry. This careful planning before the job started, and the ingenuity promptly displayed to meet the engineering and construction problems that developed because of new conditions that were found as the job went on, demonstrated a degree of elose collaboration of engineering and construction people that could be applied to all construction work to the mutual advantage of owner and contractor. Thorough planning, both before the job started and as it progressed, is apparent, and without it I believe the enviable record of getting in and out and completing the job in 12 weeks could not have been approached.

The ingenuity displayed in using an induced water hammer wave and salt velocity tests in the tunnel to help establish the nature of the obstructions is worthy of special notice and commendation.

I well recall the many theories advanced to account for the apparently mysterious performance of the tunnel after 1956. The reconstruction of events and their effects in this paper provides a rational explanation consistent with the observed data.

The opportunity to make detailed appraisal of the condition of a large water tunnel after years of service seldom arises, giving little chance to compare design assumptions with reality and to compare with certainty the effectiveness of types of tunnel protection methods. Kemano Tunnel, with some mass concrete lining, with a variety of thicknesses of plain gunite lining, and with some tunnel with no lining, offered a unique comparison of these different grades of protection. The demonstrated effectiveness of even thin gunite in preventing progressive erosion of soft materials in the seams is striking. The obvious conclusion is that the gunite acted not as a structural support but as a membrane seal that prevented the start of evacuation of erodible seam material. Without erosion of seamy material, there was no loosening of the blocky roek and the residual lateral stresses maintained a natural arch. Thus, material of this general character, whieh is frequently encountered in tunnel excavations, can be adequately protected against future failures by a thin gunite layer, assuming the gunite continues in intimate contact with the rock surfaces and seams. Modern practices of guniting against wire mesh held in place by short rock bolts or pins should prevent the only apparent hazard remaining, that of spalling which might expose erodible seams. Since loosening of this kind of rock structure in tunnels exposed to air frequently occurs progressively due to drying shrinkage of the material in seams, the use of gunite as a membrane seal should be as effeetive in air as it has been demonstrated to be in water.

Many more phases of the work and findings described in this paper are worthy of special comment, but I do not wish to dilute with additional words the exeellent work of the authors. Perhaps the paper does not convey the amazement and consternation the authors must have felt when they encountered the cavern, high enough for a 14 storey building, but, by cus-

tom and tradition, emotions have no place in engineering papers. I do congratulate the authors on an outstanding job and thank them for making the experiences and the data a part of professional literature.

Author's Reply

The number of written and oral discussions by engineers of prominence is taken by the authors as a tribute which they very much appreciate and wish to gratefully acknowledge. These discussions certainly enhance the value of the paper.

The discussion by Gorman and Jenkner and to some degree that of Lambert, question the general use of unlined tunnels, or the extra cost of tunnel lining.

Gorman and Jenkner have reconstructed the Kemano experience as it might have affected an electric utility and conclude that "A decision for a public utility might be rather heavily influenced in favor of a lined tunnel". It is considered by the writers that initial operation of the tunnel at full flow would have resulted in a different operating history. The purpose of this paper was to contribute to the improved reliability and economics of future unlined tunnels. At Kemano the rockfall began early, but the operation of the tunnel at low flow made excessive head loss difficult to measure and of no importance until after seven years of operation. A utility tunnel would, in all probability, begin operation at full peaking capacity. Such operation would immediately show the presence of a hydraulic obstruction before it progressed far and repair would be relatively minor. However, more important, the adequate treatment of seams in future tunnels should make the probability of progressive rockfalls very remote.

The assumption made by these discussors that in the Kemano comparison no account was taken of the fact that a completely lined tunnel possessing essentially similar hydraulic performance characteristics as an unlined one, could be of substantially smaller cross section, is not correct, though the reasoning is. For example, at Kemano, when a long formation near the intake required support and lining, a 21 ft. section was driven instead of a 25 ft. section, and the unlined and lined section had about equal head loss. However, when a fault was encountered which would require support for only a short length, the driven section remained at 25 ft. and a larger lined section was used to minimize concrete, to permit rapid lining, and to minimize transition losses.

The estimated four-month delay was that which would have occurred if a decision had been made to change to an all-lined tunnel of equal head loss when more than estimated supported ground was encountered.

The $12,000,000 saving of the unlined over the lined tunnel represents an estimate of the saving of the tunnel as constructed, over an all-lined tunnel having equal head loss.

The discussion by MacDonald and Morris, by Spencer, by Dann, by Terzaghi, and by Dunn, summarizing experience with unlined tunnels of the Pacific Gas & Electric Company, Southern California Edison Company, The Snowy Mountain Hydro Electric Authority, and Aluminum Company of Canada, Limited's Chute-des-Passes tailrace tunnel, all show that unlined tunnels constructed with careful treatment of erodible seams have had no rockfalls, and are more economical than equivalent lined tunnels. These all very definitely support the point of view of the authors as outlined in the previous paragraphs.

In reply to Murchison's first question, the driving of a new tunnel around the cavern area was considered, but only as a last resort. Several considerations were involved, namely:

(a) All planning and mobilization of equipment prior to unwatering was based on the premise that it was possible to mine through the fallen section. A hard rock tunneling operation would mean re-equipping the job and losing time.

(b) Because the second tunnel planned for ultimate development of the Kemano Project would be driven on the left, the by-pass tunnel would have to be driven to the right or North side. Rock conditions within the cavern indicated the cavern would continue to enlarge northward up over the by-pass tunnel. A safe by-pass tunnel perhaps 800 ft. long would be required and would probably need full lining. This compares with the 65 ft. of cavern opening and 149 ft. of concrete lining used.

(c) Ventilation was a critical problem and the use of powder and additional compressors within the tunnel would have necessitated a full scale ventilating and blowing installation similar to that used during tunnel driving.

(d) Additional time would have been required and the cost would have been much greater.

Murchison will note from the paper that muck filled over half the tunnel cross section for a distance of 2,600 ft. downstream of the cavern. Since

(Continued on next page)

• Discussion

(Continued from page 85)

the cavern area was already filled higher than the crown, a limited quantity of muck could have been placed between plugs.

The paragraph referred to in Murchison's second question was not intended to convey that rock falls occurred only in ungunited areas. As mentioned in the paper, almost all falls of consequence occurred in a 6,000 ft. length of tunnel upstream of Horetzky adit where at least some gunite had been applied, although not always over the full perimeter. Many seams which required repairs were also in areas upstream of Horetzky adit where gunite was irregular and thin. It is interesting to note that the ¾ in., uniformly thick gunite downstream of Horetzky successfully resisted deterioration except at the major cavern and a very few seams of little importance.

Immediately downstream of the major cavern, gunite was intact in spite of evidence of violent battering by rocks moved by high velocity water.

Lambert emphasizes the ventilation question. The paper specifically mentions the vent duct through the main cavern and refers to power driven fans at each end of the tunnel. Certainly, this was one of the many problems which had to be solved. Actually, as suggested by Matthias, all major items and decisions regardless of their nature were acted upon with unanimous agreement between contractor, engineer, and owner.

Lawton and Lester mention two other interesting events, i.e. the tunnel draining and filling. There were many such facets to the complete work and space does not permit including them all.

In reply to MacDonald and Morris, the Tahtsa Lake water has a ph of 7.3. It was considered by the geologists that solubility of the fault materials in running water, and the mechanical action of this water were the cause of the same erosion. No vibration was noticed or considered to contribute.

Spencer's discussion says in effect that the experience with 42 miles of unlined tunnel having ages five to 50 years has shown three cases of rock falls, each caused by erodible seams. This discussion which carefully presents the useful lessons in their experience makes no mention of the three years of trouble-free operation of the Mammoth Pool unlined tunnel eight miles long and of 21 ft. horse-shoe section.

The review of the Snowy Mountain experience by Dann is equally valuable.

Terzaghi's discussion is very much appreciated and pertinent. The authors agree rock dentistry cannot be written into specifications, yet it is done successfully, as borne out by the experience summarized by the discussors of this paper. Specifically, at Kemano, the engineer had several competent inspectors in the tunnel on each shift working in close cooperation with the crews, which was of great help. The objective of the contractor was to execute work of high quality, and the owner stressed that the work must be properly performed.

The discussions by Dunn and by Matthias bring out additional aspects of the paper and show understanding of the problems involved, and are much appreciated. EIC

Meetings of Special Interest to E.I.C. Members

AUGUST 24-25
Baie Comeau Technical Regional Conference at Baie Comeau

SEPTEMBER 6-7
Maritime Professional Engineers' Conference at Digby, N.S.

SEPTEMBER 12-14
(Zone "A" Regional Technical Conference)
SEPTEMBER 12-13
(Sixteenth Soil Mechanics Conference)
Joint at Edmonton

OCTOBER 22-24
Joint CIC-EIC Chemical Engineering Divisional Technical Conference at Sarnia

FALL OF 1962
Newfoundland Regional Conference

EARLY DECEMBER 1962
Northwestern Ontario Regional Technical Conference at Fort William

FALL OF 1963
St. Maurice Valley Regional Technical Conference at Grand'Mere

Consulting Services

Denotes Membership of a Principal in the Association of Consulting Engineers of Canada

INDEX TO ADVERTISERS

AUGUST 1962

PUBLICATION OFFICES: The Engineering Institute of Canada, 2050 Mansfield Street, Montreal 2, Quebec, Canada.

Association of Consulting Engineers of Canada Incorporated

The following firms have principals who are members of this Association engaged as professional engineers in engineering work independent of salaried employment or sales promotion.

The revenue derived from the sale of advertising space assists the Institute in publishing THE ENGINEERING JOURNAL on a regular monthly basis. Listed above are the names of the Companies and individuals whose advertisements appear in this issue.

ADVERTISING OFFICES

QUEBEC: J. E. Donovan, Manager, Advertising Sales. Representative—Charles R. Amey, 2050 Mansfield Street, Montreal, Phone: Victor 2-8121
ONTARIO: W. Morrison Day, 160 Eglinton Ave. E., Suite 103, Toronto, Phone: 485-0789
WESTERN CANADA: W. George Turner, 501 - 191 Lombard Ave., Winnipeg, Man., WH 3-9123
UNITED KINGDOM: H. A. Mackenzie, 4A Bloomsbury Square, London, W.C.1, England. Phone: HOlborn 3779
EUROPE: Gustav Elm, 41 Avenue Montaigne, Paris 8, France. Georg Linder, Wittelsbacher Allee 60, Frankfurt Am Main, West Germany.
NEW ENGLAND STATES: R. G. Melendy, 17 Maugus Avenue, Wellesley Hills 81, Mass. Phone: CEdar 5-6503
CHICAGO: W. Reynold Ratz, 549 W. Randolph St., Chicago 4, Ill. Phone: ST-2-8811
NEW YORK: John H. Boyd, 17 East 45th Street, New York, Phone: MUrray Hill 7-0654
CALIFORNIA: Dunkle/Lehman Company, 740 South Western Ave., Los Angeles, Calif. Phone: DUnkirk 7-6149

EIC

President
F. L. LAWTON, M.E.I.C.
Treasurer
A. W. HOWARD, M.E.I.C.
General Secretary
GARNET T. PAGE, M.E.I.C.

THE
ENGINEERING JOURNAL

VOLUME 45 NUMBER 9 SEPTEMBER 1962

UBLISHED MONTHLY BY THE ENGINEERING INSTITUTE OF CANADA, 2050 MANSFIELD ST., MONTREAL 2, QUE., CANADA • TEL. VI. 2-8121

Printed in Toronto

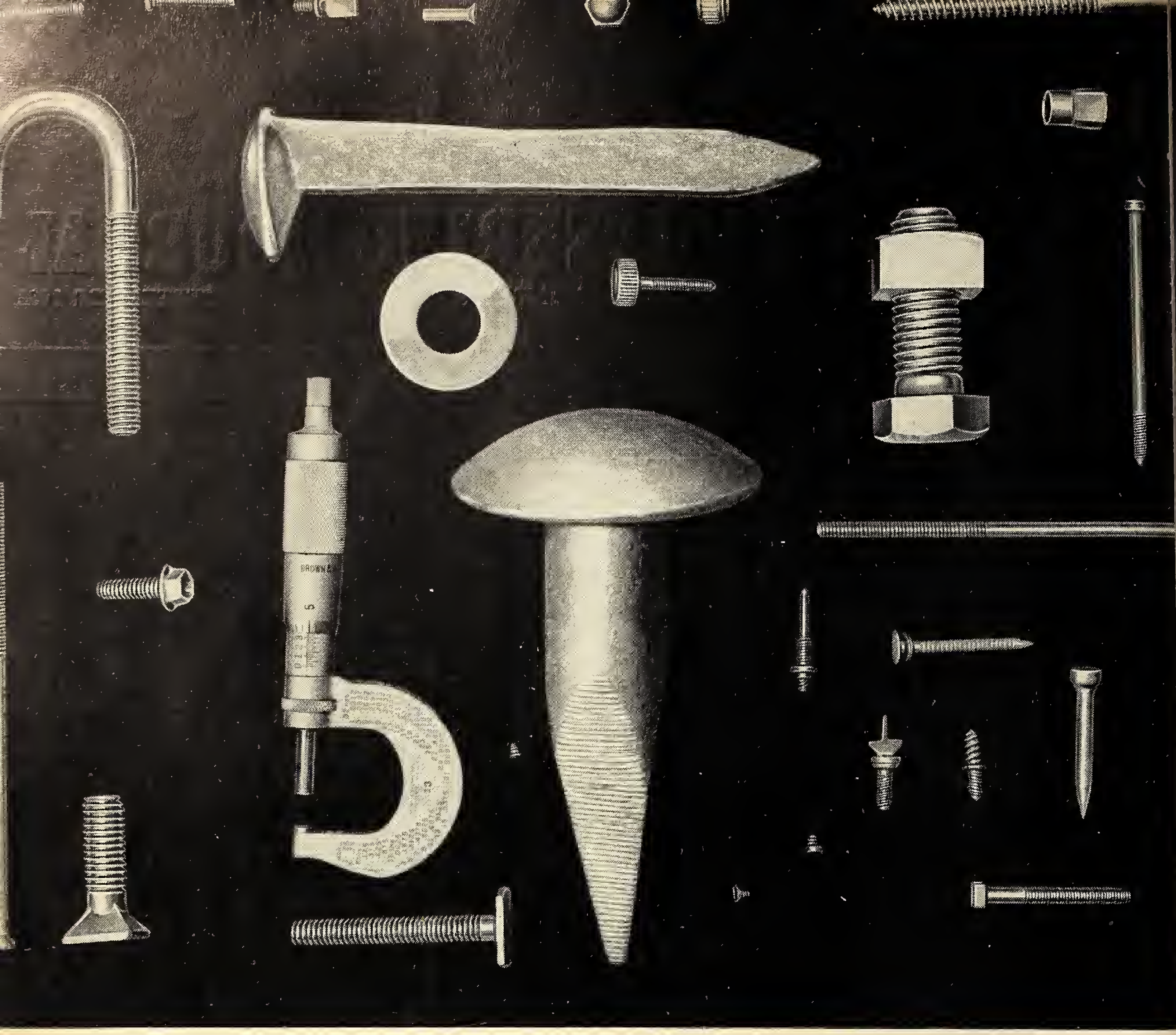
Price $6.00 a year in Canada, British Possessions, United States and Mexico. $7.50 a year in Foreign Countries. Current issues, 75 cents a copy, back issues from $1.00 per copy up. To members, affiliates and other bona fide engineers in Canada—no charge. Authorized as second class mail, by the Post Office Department, Ottawa, and for payment of postage in cash.

MEMBERSHIP

CCAB BNA

Indexed in
The Engineering Index
The Applied Science
and Technology Index

CONTENTS



IN THIS ISSUE

In his paper, "*75 Years of Structural Steel*", W. C. Kimball, Assistant Chief Metallurgist, with the Algoma Steel Corporation Limited, Sault Ste. Marie, Ont., surveys the use of structural steels from the first steel framed building in Chicago on 1888, to the latest buildings and bridges under construction in 1962. Mr. Kimball discusses the steel specifications used, and the development of the early specifications into the present steels is followed. Auxilary uses of steel, other than as framing members, are also developed, leading to present day all steel construction methods. The latest steel specifications are reviewed and some predictions are made of the structural steel specifications for the foreseeable future.

M. Kert, in his paper, ***"The Mechanical and Electrical Services for the Place Ville Marie Development"***, describes the seven acre commercial complex in Montreal. The complex comprises a base of two floors of garage and storage area and a shopping promenade, plaza, plaza shops, Royal Bank of Canada office building, four Royal Bank quadrants, three-storey Cathcart office building with shops at plaza level. The mechanical services for the Royal Bank Building are located in the lower mechanical floor and the upper penthouse. Steam is supplied to the Project by the C.N.R. at 400 p.s.i. and is reduced to 30 p.s.i. for final use. Domestic water supply is provided from the city water lines by two eight-inch services from University Street. The water is stored in a tank located at track level and is pumped directly to the Cathcart building and to house tanks on the 27th floor and penthouse of the Royal Bank Building. The lower levels are fed directly from the street. Uppermost floors, and the observation tower of the Royal Bank Building are fed by a hydropneumatic system. The C.N.R. track area has an exhaust ventilation system to remove fumes from the diesel engines and discharges this air to atmosphere at the roof of the Cathcart Building. The garage areas have supply exhaust ventilation to control carbon monoxide concentration and to remove gas fumes. Store areas are air conditioned with individual fan coil compressor units provided with cooling tower water from two towers located on the roof of the Cathcart Building. Hydro service is supplied to the site from 12 kv. 3/60 service, and drops to a main switchboard and metering room at track level. 12 kv. feeders rise to the lower mechanical floor of the Royal Bank Building, and the second mechanical penthouse, and feed four transformer banks of 5000 kv. each. 12kv./550/3/6. feeders serve two electrical closets on each floor of the tower. Dry core 500/12/208 transformers and panelboards and metering facilities are provided for each closet. Emergency power for the lower levels is provided by a 500 kv. diesel.

Canadian economic development is imposing some important changes on requirements for engineering manpower and on how such manpower is utilized.

In his paper entitled ***"Engineers in the Canadian Economy"***, **J. P. Francis**, Director, Economics and Research Branch, Department of Labour, Ottawa, states that jobs for engineers have been growing at a more rapid pace than total employment for several decades but, in the last ten years, a significant change has occurred in the factors determining this growth. Until the 1950's, engineering manpower requirements came mainly from the overall growth of the economy and the fact that the industries already employing engineers were the fastest growing ones.

In contrast to earlier decades, there have been substantial increases over the past ten years in the proportion of engineers in the work forces of many industries. Needs for engineers are being generated by the changing character of industry due principally to technological developments.

Extensive facilities have been developed in Canada for the education of engineers, while limited ones were provided for the training of technicians, and the education of business, financial and organizational specialists. As a result, engineers have been employed extensively in these fields. Now, facilities are being expanded for the training of technicians and at the university level for a growing number of social scientists and others with special preparations for the business world. These trends will have important effects on the engineering profession. In the future, greater emphasis will need to be put on the development of university facilities at the post-graduate level in the engineering field, and ways and means will have to be developed whereby engineers already in the labour force can keep abreast of technical and scientific developments.

In the future, the characteristic of engineering education will be an extensive understanding of scientific principle on top of which will be built some specialized technical knowledge.

G. F. Pearce, M.E.I.C., Assistant Professor of Mechanical Engineering, University of Waterloo, has written a paper, ***"The Production and Use of an Animated Film for Teaching Kinematics"***, which deals with the actual production of the film, the drawings used for animation, the photographic techniques and the equipment used. The film shows the displacements, velocities, and accelerations in a four-bar basic mechanism. The method of obtaining the accelerations using a digital computer are explained. The particular conditions of maximum velocity and maximum acceleration are strikingly portrayed when viewing the film and the superiority of the animated presentation over the usual static presentation is evident.

"Foundation Failure of a Silo on Varved Clay," by **W. J. Eden**, M.E.I.C., and **M. Bozozuk**, M.E.I.C., Research Officers, Soil Mechanics Section, Division of Building Research, N.R.C., Ottawa, describes the collapse of a farm silo founded on normally consolidated varved clay near New Liskeard, Ont. The silo suddenly collapsed in July, 1961, the day after being filled to capacity. The 50 ft. high silo was founded at a depth of 4 ft. on a 22 ft. diameter concrete beam. Base loading was about one ton per square foot. The required shearing resistance of the subsoil according to bearing capacity theory is compared with field and laboratory measurements of shear strength.

Many areas of engineering today have experienced significant extensions of knowledge during the past decade. This poses a problem for the engineering teacher, i.e., how to get the student to absorb more material in the alloted time. One solution to the problem is to use more effective visual aids which give the student such a clear conception of the elementary principles that he can progress to the advanced work more rapidly.

COVER ILLUSTRATION

Shown is the steel superstructure of the new $4,000,000 wing at the General Hospital at Sault Ste. Marie, Ont. Photo courtesy of Algoma Steel Corporation Limited.

CALL THE MEN FROM EMCO FOR PIPE FITTINGS AND VALVES ON THE DOUBLE! Wherever you are, whatever your need, call the men from Emco and they'll get it to you on time, every time. Sound like a dream? Well, call Emco and see it come true! Emco puts the emphasis on **service.**

EMCO LIMITED

Branches across Canada to serve you.

75 YEARS OF STRUCTURAL STEEL

W. C. Kimball
Assistant Chief Metallurgist,
The Algoma Steel Corporation Limited.

THIS YEAR we are celebrating the 75th Anniversary of the Engineering Institute of Canada. By coincidence, we are also celebrating approximately the 75th Anniversary of the first all-steel structure. This is all the more a coincidence when we realize that buildings and bridges have been constructed for some 4,000 years and that steel has been known for some 3,000 years, and yet it was only in the very recent past that this outstanding metal was applied to the construction of buildings and bridges.

While steel was known and its properties were used for many articles for centuries, it was not until the 19th century brought large scale steel manufacturing methods into use that pieces of steel, large enough, and cheap enough, were available to be of any value in the construction industry.

The first recorded structure using steel was a bridge built in Austria, in 1833, which was supposed to have used steel eye-bars. There is some doubt, however, as to whether these were steel or wrought iron; but there is definite proof that steel was used in bridges for a considerable period before it was used in building construction. As a matter of fact, some tonnage of cast steel plates were used in the construction of the Niagara River Suspension Bridge, which was built about 1860.

The most widely publicized of the early steel bridges is the famous Eads Bridge over the Mississippi River. While much has been said about its alloy steel construction, it has now been shown that only a portion of the structural members were steel and that the alloy content of these members was almost insignificant. The strength of the cast tubular steel members was largely the result of high carbon contents. As a matter of fact, test results of the carbon steels used in this bridge show tensile strengths running up to as high as 120,000 p.s.i. I am sure that many designers would shudder at the thought of using such a material in modern bridge construction, but that bridge is still standing.

Probably the first all steel bridge of any size was the famous Firth of Forth Bridge completed in 1889. This bridge was of all steel construction, fabricated from cast steel tubular sections. All told, some 42,000 tons of steel were used in this structure. There is no test data available on the material used in this bridge; however, steel produced in the British Isles at that time normally had a tensile strength of between 50-58000 p.s.i. The British Board of Trade had ruled that the maximum allowable working stress should not exceed 6½ tons p.s.i. This would appear low to modern designers until it is realized that wrought iron, which was the previously used material for tension members, had an allowable stress of only five tons p.s.i. This 30% increase in the working stress was not the result of the increased strength of steel, but it was pointed out by the Board of Trade that steel members were more homogeneous and were free of flaws.

In this period a momentous change was taking place in Chicago. The world's first true skyscraper was erected using an all metal framework. While only the top four floors of this 10-storey building were fabricated of steel, it is the first recorded use of structural steel in a building. This 10-storey building was soon followed by a 14-storey building with an all-steel frame. Shortly afterwards steel became an accepted structural material for tall buildings.

Steel was not, however, finding ready acceptance by all designers. In 1884, before the Franklin Institute, a noted bridge consultant said that in the civil engineer's province of bridges, viaducts, and similar structures, he would prefer the old standby "good wrought iron". He felt that steel needed for bridge purposes was not yet a commercial product, and in compression members he had not yet seen any evidence to show that steel was as strong as wrought iron. There was probably good reason for his mistrust. Little was known about the effect of the chemical content upon the strength of the steel, and very much less was known about the effects of rolling variables and handling of the steel. In fact, in that period there were very few testing machines capable of carrying out tensile tests on specimens large enough to have any meaning.

One of the earliest studies of the effect of the chemical content upon the strength of steel was made by a Mr. Christie (Table 1), and this was reported to the American Society of Civil Engineers in 1884. Those who are used to looking at present day test reports will notice that there is a wide deviation between the results reported by Mr. Christie and the results that could be expected at the present time for the same carbon content. Unfortunately, Mr. Christie did not report any analysis other than the carbon content, and I am sure that the balance of the chemical content would leave something to be desired by present day standards. We can assume that the manganese content was very low and that the phosphorus content was probably in excess of 0.1%. This would account for the high strength levels at the low carbon contents shown, and also for the low percentage of elongation for the corresponding elastic limits.

TABLE I

Effect of Carbon Content

Upon Strength of Steel—Christie 1884

Carbon Content	*Ultimate Strength*	*Elastic Limit*	*Elongation in 10 ins.*
0.10%	60,000 PSI.	36,000 PSI.	26%
0.15%	66,000 PSI.	40,000 PSI.	24%
0.20%	74,000 PSI.	45,000 PSI.	22%
0.25%	82,000 PSI.	50,000 PSI.	20%
0.30%	90,000 PSI.	55,000 PSI.	18%
0.35%	100,000 PSI.	60,000 PSI.	16%
0.40%	110,000 PSI.	65,000 PSI.	14%

Of particular interest to Canadians is the steel specification, (Table 2),

TABLE 2

Steel Specification

Stoney Creek Arch C.P.R. 1893

Phosphorus	0.065 Max.
Managenese	0.50 Max.
Ultimate Strength	58,000-65,000 PSI.
Elastic Limit	33,000 PSI. Min.
Elongation (in 8 in.)	20% Min.
Reduction in Area	40% Min.

for the Stoney Creek Arch Bridge constructed for the C.P.R. in 1893. It would be nice to think that Canadian designers had the foresight to come up with such an excellent material specification; however, we must face the fact that this bridge was designed in England, and that the material specification is probably a modification of the British Admiralty specification issued in 1884.

This British Admiralty specification, (Table 3), was probably the first steel material specification issued by a non-producing organization. Prior to that time the material specification was largely left up to the producer and he supplied a material that would be suitable, in his estimation, for the design strength specified by the designer. Nevertheless, we must congratulate the C.P.R. for their excellent judgment in their choice of designers. This bridge, 280 ft. high, with a 336 ft. span, was the largest high arch bridge in the world at the time of its construction.

TABLE 3
British Admiralty Structural Steel Specification
1884

Ultimate Strength	26-30 Tons PSI.
Elongation (in 8 in.)	20%

It was not until 1896 that any degree of uniformity was reached in steel material specifications. At that time the Association of American Steel Manufacturers issued a standard steel specification for buildings. This standard, (Table 4), recognized two grades of steel, the choice of which was left up to the designer. Although phosphorus was recognized at that time to be an undesirable element, since this specification was prepared by producers it will be seen that a very high maximum limit was set on the phosphorus content. This was, however, an improvement on material that had been supplied prior to that time. Shortly afterwards a specification was produced for structural steel for bridges, (Table 5), in which the effect of phosphorus was recognized and a limit of 0.06% maximum was placed on the phosphorus content.

TABLE 4
Association of American Steel Manufacturers
Steel Specification for Buildings—1896

Phosphorus . . . . 0.10% Max.

	Soft Grade	*Medium Grade*
Ultimate Strength	52,000-62,000 PSI.	60,000-70,000 PSI.
Yield Strength	32,000 PSI. Min.	35,000 PSI. Min.
Elongation (in 8 ins.)	25% Min.	22% Min.

TABLE 5
Association of American Steel Manufacturers
Steel Specification for Bridges—1896

Phosphorus . . . . 0.06% Max.
Sulphur . . . . 0.06% Max.

	Soft Grade	*Medium Grade*
Ultimate Strength	52,000-62,000 PSI.	60,000-70,000 PSI.
Yield Strength	32,000 PSI. Min.	35,000 PSI. Min.
Elongation (in 8 ins.)	25% Min.	22% Min.

At the same time that the industry was trying to standardize on material specifications a move was undertaken to standardize on the sizes and shapes produced. In the early days each steel producer rolled his own sections to whatever dimensions he thought best. The industry did get together in 1896 to prepare a standard list of structural shapes. This list of beams, angles, and channels has changed but little in all the years since that time.

To show that Canadians in that day were the same far-seeing individuals that they are at the present time, the Dominion Government issued a steel specification for bridges in 1899, (Table 6), which limited the phosphorus and the sulphur contents to 0.04%. This was a radical tightening of the North American practice at that time, and looking at this specification one can see that there is very little difference between the medium grade specified at that time and our current CSA G 40.4 steel. This would seem to indicate that either the government officials responsible for this specification were extremely far sighted or that the steel industry has been standing still for some period. There is probably truth in both of these statements.

TABLE 6
Dominion Government Steel Specification for Bridges—1899

Phosphorus . . . . 0.04% Max.
Sulphur . . . . 0.04% Max.

	Soft Grade	*Medium Grade*
Ultimate Strength	50,000-58,000 PSI.	60,000-68,000 PSI.
Yield Strength	30,000 PSI. Min.	32,000 PSI. Min.
Elongation (in 8 ins.)	25% Min.	22% Min.

National and international specification writing bodies started to appear in the 1890's. In 1893 the American Society for Mechanical Engineers sent a representative to such an international meeting in Vienna, and in 1895 the International Association for Testing Materials was created and an American Section was formed. There were several Canadian members of this American Section at that time.

In May, 1900, the American Section of the International Association for Testing Materials proposed a specification for structural steel for bridges, (Table 7). This is only slightly different from the specification produced by the Association of American Steel Manufacturers, but limitations were placed on the phosphorus and sulphur contents, and the use of Bessemer steels were prohibited by this specification. It would have been wise if some later designers and fabricators had noted this fact. Later the same year a standard was proposed for structural steel for buildings, (Table 8). In this case Bessemer steel was permitted and the higher phosphorus content was allowed. It was not until 1909 that a lower phosphorus content was insisted upon for building construction.

TABLE 7
International Association for Testing Materials American Section
Proposed Standard Steel for Bridges—May 1900
Open Hearth Steel Only

Phosphorus . . . . 0.06% Max.
Sulphur . . . . 0.06% Max.

	Soft Grade	*Medium Grade*
Ultimate Strength	52,000-62,000 PSI.	60,000-70,000 PSI.
Yield Strength	0.5 x US. Min.	0.5 x US. Min.
Elongation (in 8 ins.)	25% Min.	22% Min.

LATER ASTM A-7

TABLE 8
International Assoc. for Testing Materials American Section
Proposed Standard Steel for Building—1900
Open Hearth or Bessemer Steel

Phosphorus	0.10% Max.
Ultimate Strength	60,000-70,000 PSI.
Yield Strength	0.5 x U.S. Min.
Elongation (in 8 ins.)	22% Min.

LATER ASTM A-9

The steel construction industry took a major step forward in 1902 when, on the original Grey mill in Luxembourg, wide flange beams were rolled for the first time. A number of sizes were produced up to 12 in. x 29 in. The efficiency of the wide flange beam was soon recognized and universal beam mills were installed in the United States for the production of these shapes.

The first all-steel framed structure in Canada was constructed in 1906, and is still standing on Yonge Street in Toronto. The delay in Canadians using this multi-storey type of construction was probably due not so much to Canadians' slowness as to the British influence at that time.

TABLE 11

American Society for Testing Materials

Low Alloy Structural Steel—1941

Carbon	0.20% Max.
Manganese	1.25% Max.
Sulphur	0.05% Max.

	Thickness 3/16" to 3/4"	over 3/4" to 1½"	over 1½" to 2"
Tensile Strength	70,000 PSI. Min.	66,000 PSI. Min.	63,000 PSI. Min.
Yield Point	50,000 PSI. Min.	45,000 PSI. Min.	40,000 PSI. Min.
Elongation	1,500,000/TS (in 8" Min.)		

ASTM A-242

The British thought was well expressed by Charles Childs in a paper presented to the Royal Architectural Society in 1898. He said, "It is appalling to think what the streets of London, already in so congested a condition, would be like were it permitted to erect buildings 15 or 20 stories high". I don't think Mr. Childs could ever have conceived of real traffic congestion.

In the years following 1910 steel producers, fabricators, and designers were extremely busy at their jobs of erecting more and more multi-storey buildings. A number of outstanding Canadian buildings were erected in this period, including the Sun Life Building in Montreal, the Bank of Commerce Building in Toronto, the Royal York Hotel in Toronto and the Pickett Building in Hamilton.

TABLE 9

American Society for Testing Materials

Specifications for Structural Nickel Steel 1912

Carbon	0.45% Max.
Manganese	0.70% Max.
Phosphorus	0.04% Max.
Sulphur	0.04% Max.
Nickel	3.25% Max.
Ultimate Strength	85,000-100,000 PSI.
Yield Point	50,000 PSI. Min.
Elongation (in 8 ins.)	1,500,000/U.S. Min.

LATER ASTM A-8

Steel specification writing bodies, however, were resting on their laurels. True, several high strength structural steel specifications had been written, primarily for bridge construction. The specification for structural nickel steel, later ASTM A-8 (Table 9), was adopted in 1912, and was first used on the Queensboro Bridge in New York; and the specification for structural silicon steel, later ASTM A-94, (Table 10) was approved in 1925, although steel of this type had been first used in 1907 in the construction of the Steamer S.S. Mauretania. The so-called high-strength low-alloy structural steels first made their appearance in 1941 as a standard specification (Table 11). They had been sold for some time previously under the various producer's specifications.

Canadian structural steel specifications were issued first in 1935 by the then Canadian Engineering Standards Association. The four grades of steel covered at that time, S-39, S-40, S-41, and S-42 closely paralleled the existing ASTM specifications for structural steel and rivet steel. These specifications kept their same nomenclature although the name of the organization was changed to the Canadian Standards Association. In 1950 the same series were changed to the present G 40 series but still maintained their great similarity to the ASTM specifications.

Changes in fabricating technique, however, were occurring which would soon require entirely different material specifications. Electric welding had been used as a minor tool in the fabricating industry since about 1920. It was not considered suitable for any major connections and had limited usage. As the art of welding improved, particularly with the impetus of the Second World War, it soon became apparent that electric arc welding was an ideal method of field fabrication. One of the earliest Canadian buildings using this construction technique was the Hospital for Sick Children in Toronto, constructed in 1947. This structure announced the death knell of the familiar sound of the riveter's hammer. This building was soon followed by many others fabricated by this new technique.

All of these early structures were made from the normal structural steel. While in many cases the steels were perfectly satisfactory, some fabricators were running into considerable difficulty in welding some of the material ordered to ASTM A-7 or CSA G 40.4. Since there was really nothing in either specification to prevent the use of higher carbon material, it was possible to obtain material which met all the requirements of the specification yet would not be suitable for welded construction. This was soon recognized throughout the steel industry, but a considerable period of time was required to develop a specification placing a suitable limit on the carbon content of a structural grade steel. It was not until 1954 that a specification entitled "Structural Steel for Welding" was finally approved, (Table 12). While this specification has some shortcomings, it does place a top limit to the carbon content upon plates and structural shapes. Using this material one could have reasonable assurance that there would be no underbead cracking dur-

TABLE 10

American Society for Testing Materials

Structural Silicon Steel—1925

Carbon	0.40% Max.
Phosphorus	0.04% Max.
Sulphur	0.05% Max.
Silicon	0.20% Min.
Ultimate Strength	80,000-95,000 PSI.
Yield Point	45,000 PSI. Min.
Elongation (in 8 ins.)	150,000/U.S. Min.
Reduction in Area	30% Min.

ASTM A-94

TABLE 12

American Society for Testing Material

Structural Steel for Welding

Chemical Requirements

	For Shapes and Bars to 1"	*For Large WF Beams*	*For Plates to 1/2"*	*For Plates 1/2" to 1"*
Carbon	0.28% Max.	0.28% Max.	0.26% Max.	0.25% Max.
Manganese	———	0.50-0.90	———	0.50-0.90
Phosphorus	0.04% Max.	0.04% Max.	0.04% Max.	0.04% Max.
Sulfur	0.05% Max.	0.05% Max.	0.05% Max.	0.05% Max.

Tensile Strength	58,000-75,000 PSI.
Yield Point	32,000 PSI. Min.
Elongation (in 8")	21% Min.
(in 2")	24% Min.

ASTM A-373 - 58T

TABLE 13
Canadian Standards Association

Structural Steels with Improved Resistance to Brittle Fracture

	Grade "A"	*Grade "B"*	*Grade "C"*
Carbon	0.22% Max.	0.20% Max.	0.15% Max.
Manganese	0.80-1.50%	0.80-1.50%	0.80-1.50%
Phosphorus	0.03 Max.	0.03 Max.	0.03 Max.
Sulphur	0.05 Max.	0.05 Max.	0.05 Max.
Silicon	——	0.35 Max.	0.35 Max.
Nitrogen	0.008 Max.	0.008 Max.	0.008 Max.
	Up to 5/8" Thick	*Over 5/8" to 1" Thick*	*Over 1" to 1¼" Thick*
Tensile Strength	65,000-85,000 PSI.	65,000-85,000 PSI.	65,000-85,000 PSI.
Yield Point	40,000 PSI. Min.	38,000 PSI. Min.	36,000 PSI. Min.
Elongation (in 8")	20% Min.	20% Min.	20% Min.

CSA G40.8

ing fabrication by welding. This specification was quickly accepted by bridge designers and many welded highway bridges have been constructed in Canada using this material.

In the years following the Second World War considerable thought was given to the problem of brittle fracture of structural materials. While this problem did not originate with welded material, it was certainly brought to the forefront by this fabricating technique. One of the earliest failures of a structure which we can now recognize as a brittle fracture was that in a molasses tank in Boston, in 1919. A considerable study was made at that time since there was a great loss of life involved in this failure. This was a riveted structure; however, the circumstances and the method of failure would serve to establish this as brittle failure. Several of the early welded bridges in Europe failed when only very lightly loaded because of brittle fracture.

Of course, the factor which brought brittle fracture into the limelight was the failure of Liberty ships during the Second World War. At that time a considerable number of ships suffered some damage and in several cases complete loss of the ships resulted. On the basis of this, several organizations did a large amount of research into the problem of brittle fracture.

Without going into the details of why fracture occurred, it is sufficent to say that the effects of some design and material factors were disclosed. Basically, it was shown that failure resulted from design notches, excessive restraint of material with resultant locked-in stresses, and materials having high transition temperatures as measured by the standard impact test. The problems of design and restraint of material, of course, were left to the designer, but the problems of materials found their way eventually to the steel producers. Among the steelmaking factors which were known to have resulted in brittle fracture were high carbon contents, high phosphorus contents, high nitrogen contents, rimming type steel, large grain size, and excessively high rolling temperatures. When all of these factors were studied it became apparent why, in the early days, the use of Bessemer steel had been condemned for bridges. Although these studies received considerable attention in the shipbuilding industry, no great interest was aroused in the construction industry in the United States.

In Canada, where definite problems have existed with cold temperatures, both during fabrication and during service, considerable pressure was brought to bear to produce structural steels which would be suitable for a welded structure in any location in Canada. This culminated in the adoption of the CSA standard G 40.8, (Table 13), of which much has been written. These steels offered Canadian designers and fabricators material entirely suitable for welded bridges and buildings for use in the cold temperatures to which we Canadians have become accustomed. As a matter of interest these steels are so desirable that their use has spread far beyond the construction industry to which they were first intended and they have now been used in pipelines, storage tanks and machinery.

In the past several years the specification writing bodies have been extremely busy with new specifications for structural steel material. Because of the increased competition from other building materials, demands were being voiced constantly by structural designers for more economical, higher strength steels so that higher allowable working stresses could be used. In 1959 a high manganese, high strength structural steel was approved by ASTM, (Table 14), which merely confirmed a number of proprietary grades which had been offered previously, and in 1960 the high-strength low-alloy manganese-

TABLE 14
High Strength Structural Steel A-440

C0.28% Max., MN 1.10-1.60% P0.04% Max., S0.05% Max., Si0.03% Max., CR0.20% Min.
Tensile 70,000 PSI. Min., Yield 50,000 PSI. Min. Elongation (8") 18% Min.

High Strength Manganese Vanadium Steel A-441

C0.22% Max., MN 1.25% Max., P0.04% Max., S0.05% Max., Si0.30% Max., CR0.20% Min., V0.02% Min.
Tensile 70,000 PSI. Min., Yield 50,000 PSI. Min. Elongation (8") 18% Min.

High Strength Structural Steel A-94

C0.33% Max., MN 1.10-1.60%, P0.04% Max., S0.05% Max., Si0.30% Max.
Tensile 75,000 PSI. Min., Yield 50,000 PSI. Min., Elongation (8") 17% Min.

TABLE 15
American Society for Testing Materials

Specification for Structural Steel—1960

	Shapes Plates and Bars	*Plates Over 3/4"-1½"*	*Plates Over 1½"-4"*	*Bars Over 3/4"-4"*
Carbon	0.28 Max.	0.28 Max.	0.28 Max.	0.28 Max.
Manganese	——	0.80-1.10	0.85-1.20	0.60-0.90
Phosphorus	0.04 Max.	0.04 Max.	0.04 Max.	0.04 Max.
Sulphur	0.05 Max.	0.05 Max.	0.05 Max.	0.05 Max.
Silicon	——	——	0.15-0.30	——

Tensile Strength .... 60,000-80,000 PSI.
Yield Point .... 36,000 PSI. Min.
Elongation (in 8") .... 20% Min.
(in 2") .... 23% Min.

ASTM A-36

TABLE 16

Ultra High Strength Types

TI C0.10-0.20, MN 0.60-1.00, S10.15-0.35, CU 0.15-0.50
MO 0.45-0.60, CR 0.40-0.80, NI 0.70-1.00, V0.03-0.10, B 0.002-0.006.
Tensile 115,000 PSI. Min., Yield 100,000 PSI. Min. Elongation (2") 18% Min.

N-A-XTRA-100
C 0.10-0.20, MN 0.60-1.00, S 10.50-0.90,
MO 0.15-0.25, CR 0.45-0.85, ZR 0.03-0.15
Tensile 115,000 PSI. Min., Yield 100,000 PSI. Min., Elongation (2") 18% Min.

AND OTHERS

TABLE 17

Columbium Types

AWX-50, EX-TEN 50, GLX-50-W, INX-50, JLX-50-W.
PITT-TEN X-50-W, REPUBLIC X-50-W, YOLOY 50-W.

Also 45, 55, and 60 Grades

ALL APPROXIMATE
C 0.10-0.20, MN 0.30-1.00, CB 0.01-0.04
Tensile 65,000 PSI. Min., Yield 50,000. PSI. Min., Elongation (8") 22% Min.

Vanadium Types

V-45, F-50, V-55, V-60, V-65
No Analysis Available at Present

V-50-Tensile 70,000 PSI. Min., Yield 50,000 PSI. Min.

vanadium structural steels were approved, giving the same high strength but with much improved weldability.

In the same year recognition was given to the possibility of obtaining higher yield strength on the common structural materials resulting in the now well known ASTM A-36 specification. This specification, (Table 15), placed carbon and, in some cases, manganese restrictions on the analysis of structural material so that for the first time control of the chemical composition is maintained on our "garden variety" structural steels. In 1961 the old standby silicon structural steel A-94 was revised to include structural steels having a 50000 p.s.i. yield strength in thicknesses up to 1¼-in. At the same time this specification was also modified to make it considerably more economical to produce.

The structural steel industry has slowly developed from infancy through childhood, until we are now approaching full maturity. While we are not sure exactly what the future course of events will be, the industry, after a slow start, has moved forward with leaps and bounds. Plates, and in some cases structural shapes, are readily available in heat treated steels with a guaranteed minimum yield strength of 100,000 p.s.i., (Table 16), and in recent months there have been a number of press releases announcing inexpensive non-heat treated steels containing columbium or vanadium with yield points ranging from 40,000 p.s.i. to 65,000 p.s.i. While all of these steels are proprietary steels at the present time, (Table 17), the specification writing bodies are already at work preparing standard specifications to cover this type of material.

A major Canadian company has recently announced "mar-aging" steels, (Table 18), with minimum yield strengths of from 200,000 p.s.i. to 300,000 p.s.i. While admittedly these steels were not designed for normal structural use, this same company is carrying out extensive research work aimed at modifying this type of steel to a much more economical grade with a guaranteed minimum yield strength of 150,000 p.s.i. For some structures, such as bridges, these steels could be of great interest.

At the present time a structural steel designer has at his choice standdard specifications covering yield strengths from 24,000 p.s.i. up to 100,000 p.s.i., steels that are weldable, steels that are not weldable, steels that are corrosion resistant, steels that are not corrosion resistant, steels having good low temperature impact properties, and steels having poor low temperature impact properties. One can readily imagine the confusion that does exist, particularly since the modern concept of design is to use steels having different yield strengths, depending upon the stress levels encountered in a building, thus three or four strength levels may exist in a single structure. The present trend would only tend to increase this confusion.

One solution that has been proposed to solve this problem would be to eliminate all present structural steel specifications. (Tables 19, 20), and to write one specification covering all of the desired strength levels as well as the other characteristics that may be required, such as weldability, corrosion resistance or resistance to brittle fracture. In this case the designer would specify exactly what strength level and what other characteristics he required in each part of the structure. Such a change, of course, would not readily be adopted by the steel industry or the designer, but would seem to offer one solution to this problem that is already upon us.

Of one thing we can be sure, with the increase in skill of steelmakers, fabricators and designers we will have steel construction with us for some time in the future. This is more soundly assured because now more than ever before designers, fabricators, and producers are working as a team to make more and better steel structures.

TABLE 18

18% Nickel Maraging Steel

Nickel 18%, Cobalt 8%, Molybdenum 5%, Titanium 0.4%
Plus Aluminum, Boron, Zirconium and Calcium

TYPICAL VALUES

Tensile Strength		250,000-275,000 PSI.
Yield Strength (0.2%)		240,000-268,000 PSI.
Elongation (1 in.)		10-12%
Impact Strength—V Notch	75°F	23 ft. lbs.
	0°F.	23 ft. lbs.
	-175°F.	21 ft. lbs.
	-320°F.	20 ft. lbs.

TABLE 19

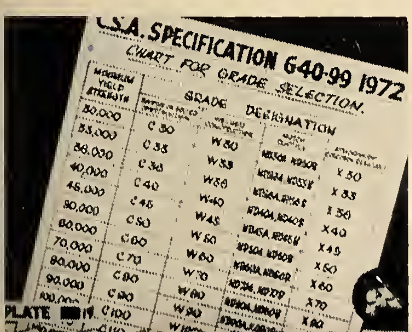
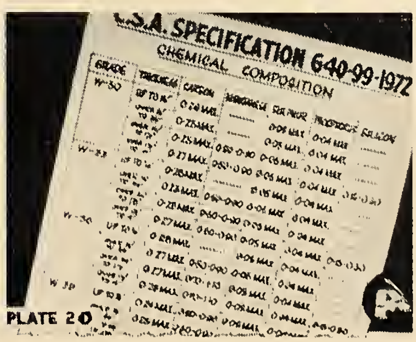


TABLE 20



THE MECHANICAL AND ELECTRICAL SERVICES FOR

The Place Ville Marie Development

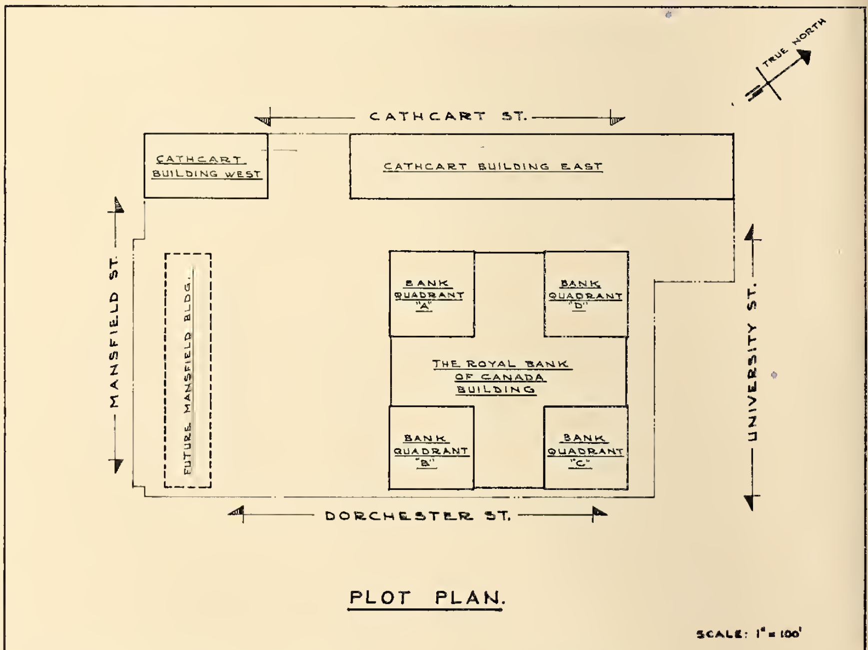
Monroe Kert,
Consulting Engineer, Jas. P. Keith & Associates, Montreal

THE PLACE VILLE MARIE development is located in the heart of Montreal. It is a large commercial complex covering seven acres and is located on the C.N.R. property north of Dorchester Boulevard. It borders on Dorchester, Mansfield, University and Cathcart Streets and links the C.N.R. Station area and Queen Elizabeth Hotel into an integrated unit. Originally thought of in 1913 when the tunnel was constructed under Mount Royal it was brought to a reality in 1955 by imaginative principals and C.N.R. acceptance of the master plans presented by Webb & Knapp (Canada), that were prepared by the architectural and planning firm, I. M. Pei & Associates. It essentially comprises of a base of two floors of garage and storage areas and a shopping promenade; plaza; plaza shops; 40 storey Royal Bank of Canada Office Building, four Royal Bank Quadrants; three storey Cathcart Office Building with shops at plaza level, and provision for a future 13 storey Mansfield Office Building.

To indicate the magnitude of this project the following approximate statistics are presented.

Total Cost	$90 million
Mechanical	$13 million
Electrical	$6.5 million
Square Feet of Office Space	1,800,000
Square Feet of Banking Space	100,000
Square Feet of Store Space	200,000
Square Feet of Garage Storage & Service Areas	450,000
Peak Total Labor Force	2,100
Peak Mechanical Sub-contractors Labor Force	500
Peak Electrical Sub-contractors Labor Force	125
Peak Professional Design Staff	200
Preliminary Architectural & Master plan	1955
Engineering Studies & Preliminary Design	November, 1957

Fig. 1.



General Contracts
Awarded . . . . April, 1958
Mechanical Sub-
contractor on Site . May, 1960
Completion of Project
Scheduled for summer, . 1962

Brief Description of Main Buildings and Areas

The largest building in the project is The Royal Bank Office Building. The lobby, entered from the plaza level, is 50 ft. high. At the base of the tower is the Lower Mechanical Floor, the height of two office floors. The tower consists of 40 floors of offices with two levels of penhouses for mechanical and electrical facilities.

There is a three-storey observation tower in the core area above the penthouses. The cruciform shape uniquely lends itself to a core area containing the mechanical and electrical facilities, toilets and lavatories, elevators and stairs. The wings provide clear office areas of maximum flexibility with clear spans of 50 ft. in one direction and 25 ft. in the other. Outside 15 ft. peripheral area is cantilevered with no columns. Exterior walls are prefabricated aluminum curtain walls with large single plate glass windows. Main structural frame is fireproofed steel. Office floor system is metal "Q" floor with concrete topping. "Q" floor serves as raceway for telephone, power and intercommunication wiring. Ceilings are metal panel with acoustical core, recessed lights and diffusers. Thirty-two elevators located in the core serve the building. Elevators are systematically programmed to cope with the varying passenger loads. They are automatic, fully supervised, operatorless, gearless type.

Each floor is approximately 40,000 sq. ft. in area.

The Royal Bank quadrants are located above plaza level at the base of the cruciform shaped Royal Bank of Canada Building. These quadrants with a gross area of approximately 100,000 sq. ft. house the main branch banking halls for the Royal Bank, together with facilities for employees, locker rooms, assembly hall, cafeteria and kitchen. The quadrants have limestone walls. Each quadrant has nine 20 ft. x 20 ft. domes in the roof for day-lighting.

The 124 ft. plaza level has access from all bordering streets. There are four retail areas located at plaza level below the bank quadrants. There are four courts with entrances from the plaza to the shopping promenade. The Cathcart Building at plaza level will contain 33,000 sq.ft. of shops.

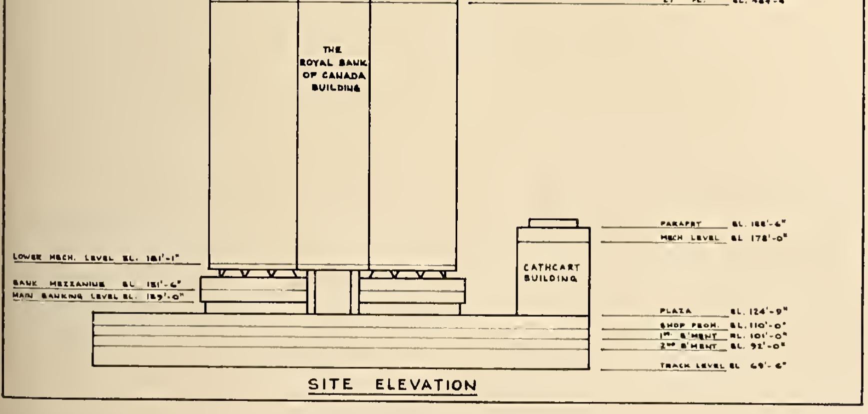
Parking facilities for 1,500 care are provided for on the 92 ft. and 101 ft. levels with entrance from Cathcart Street. Access to the Queen Elizabeth Hotel and C.N.R. Station is provided from the Cathcart Street Entrance. Truck dock entrance is at 110 ft. level from East Street on the south side of the property.

The 101 ft. level is mainly a shopping promenade with truck dock, owner's maintenance shops, theatres, restaurant and cafeteria. The 92 ft. and 101 ft. levels are mainly garage and storage areas.

The C.N.R. track area is located at elevation 69. In the area below the Royal Bank Building are train platforms. Service areas for water storage tank, electrical room and fan rooms for PVM are also located at the track level.

The Cathcart Building is divided into two sections an East and West Building. Shops are located at plaza level and upper three floors are office area with provision for future three storey extension. Building has a fireproof frame, "Q" floor system, limestone walls, single glass windows. Area per floor, east 33,750 sq. ft. and west, 11,250 sq. ft.

Fig. 2.



Steam Services.

In accordance with the Emphyteutic lease the C.N.R. furnishes all steam requirements for the PVM development. Their plant consisted of three 90,000 lb/hr. 400 p.s.i. boilers and auxiliaries. A 110,000 lb. boiler is being added together with a 1000 kva. generator to furnish power for the plant for emergency purposes. The steam plant is 5000 ft. from the PVM Mechanical Service Room. New steam and condensate mains were added from the steam plant to the C.N.R. Mechanical Room located below the C.N.R. Station. This is the central distribution point for the Station, Track Service, Terminal Building, International Aviation Building, Queen Elizabeth Hotel and Place Ville Marie site. Lines are all metered. New 10 in. and 6 in. standby steam lines and a 6 in. condensate return line were installed in the tunnel from Central Station Mechanical Room to the Mechanical Room at the 92 ft. level. Part of the tunnel was existing and part was new. As the loads imposed on the existing tunnel from anchoring of steam lines were too great for the structure and alterations costly, hinged type expansion joints were used involving three anchors only in the 1000 ft. length. The steam service lines are at the 92 ft. level, and the pressure is reduced from 320 p.s.i. $\pm$ to 125 p.s.i. for general service and then to 30 p.s.i. for utilization in ventilation and heating facilities. Safety relief valves are provided with vents rising to the Lower Mechanical Floor of the Royal Bank Building and discharging the atmosphere. Steam services are provided for the Garage areas, Store Area, Royal Bank Quadrants, Royal Bank Building, Cathcart Street Building and Alcan.

A steam loop main is provided for the stores, and services will be extended as occupancy is determined. A 125 p.s.i. steam line rises from the 92 ft. level to elevation 700 ft. of the Royal Bank Building serving the Lower Mechanical Floor and 1st and 2nd Upper Mechanical Penthouses for ventilation, air-conditioning, domestic water service and the turbo-

generator for emergency power. Due to problems of anchoring and guiding the steam line, the vertical pipe that rises express from elevation 180 ft. the Lower Mechanical Floor to elevation 700 ft. has no vertical joints, only one horizontal universal joint at the top.

All condensate is returned to receivers and pumps on the lower levels and discharged to a main condensate receiver. Condensate from upper levels drains to the main receiver. Condensate then returns by gravity to the C.N.R. receiver located adjacent to the Mechanical Room in the Station, and is then pumped back to the power plant. Condensate is metered. Steam is used directly for ventilation and air-conditioning coils, convectors, rads, fan coil cabinet heaters and unit heaters. Where steam is used in kitchens, heat exchangers are used to ensure no contamination of foods from boiler water treatment.

Sanitary and Storm Drainage Systems

The Royal Bank Building—Main sanitary drainage is from two banks of toilet and lavatory facilities located in the core of each floor. Each bank contains eight water closets, three urinals, seven lavatories, and is served by an 8 in. soil and 10 in. vent. Each wing has a wet column with a 6 in. soil and 8 in. vent. Other areas such as Observation Tower, Machine Floors, Owner's Locker Rooms have local systems of drainage that connect to the core stacks.

Vertical stacks run through each floor and terminate at the top by venting to atmosphere above the main roof. The base of the stacks are connected to two 12 in. horizontal house drains which also pick up Quadrant sanitary drainage and then run to the building wall where drains are combined with storm drains from Quadrants to run to the 5 ft. combined City sewer located on University Street.

The Royal Bank Quadrants—A separate system of sanitary stacks and vents is provided for each Quadrant for sanitary facilities, equipment drains and cafeteria waste. Drains are grouped together with Royal Bank Building drains above street level and then run to University Street.

Cathcart Building East—Sanitary facilities are grouped in two banks of toilets consisting of six lavatories, six water closets, two urinals with 6 in. stack and 6 in. vent. Facilities are made for four wet stack services. Drains are collected and combined with rain water at the base and run to University Street sewer.

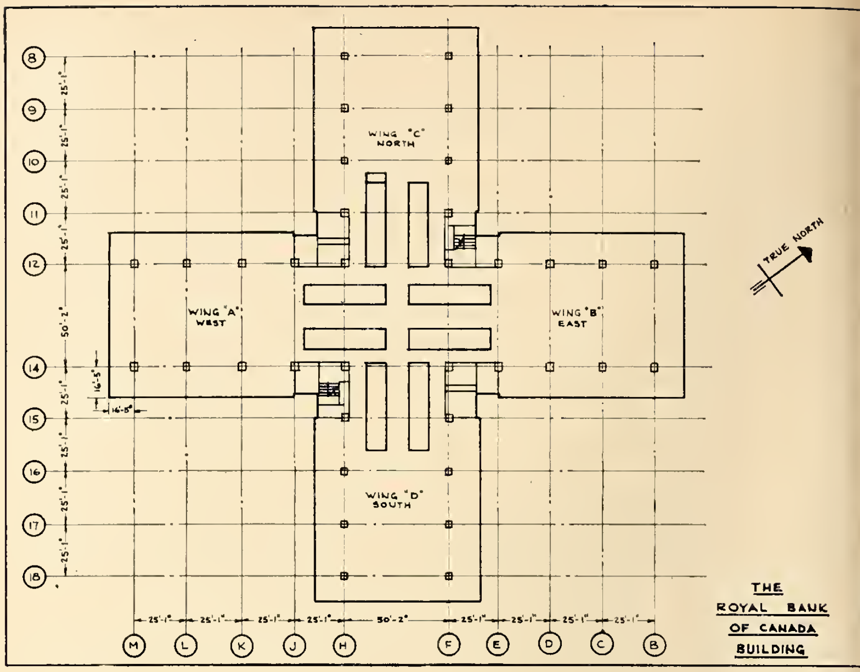


Fig. 3.

Shopping Promenade and Garage Levels—All sanitary drainage originating on these levels is collected into sewage tanks and is then pumped to house drains and flows by gravity to the street sewer. Waste drainage from garage levels below 110 ft. flows by gravity to drains located below the C.N.R. tracks through oil and gas interceptor pits and then to the C.N.R. drains which discharge to city sewers on St. Antoine Street. Drains stacks which run between elevation 90 ft. and track level 69 ft. are insulated and traced with electric heating cable as this is an unheated area.

Storm Drainage

The storm water drainage systems consist of roof drains, leaders and area drains designed to convey storm water from the roof and plaza areas to the combined city sewers in University and Mansfield Streets.

The Royal Bank Building

Six in. leaders from the roof are collected into two 10 in. horizontal storm water drains and thence routed express to the building wall where combined into one 12 in. city sewer in University Street.

The Royal Bank Quadrants

Leaders from the Bank Quadrants are sized to include drainage from the tower walls that spill onto the Quadrant roofs. Storm drainage systems from the Quadrants are collected into five 12 in. and one 10 in. drain joined at the building wall and run to the 5 ft. sewer located below University Street.

The storm and sanitary drainage from the Royal Bank Building and Quadrants require a total of four 15 in. and two 12 in. combined sewers to University. To limit the surcharge on the street, sewer connections are a minimum of 10 ft. apart.

Plaza Drainage—Drainage from the Plaza is collected in metal lined pits and conveyed through piping to city sewers in University and Mansfield Streets.

Plaza drainage is sized to take rainwater that spills from the walls of building onto the plaza.

Three specially designed metal lined pits are provided in the plaza for melting snow. Snow will be manually collected and dumped into these pits. A mobile rig with an oil burner located on the plaza discharging the hot gases through a duct will melt the snow in the pit where the water is run into collector pits, and is pumped to the drainage system.

Screwed galvanized steel piping with reeessed cast iron drainage fittings was used for storm and sanitary drainage systems in the Royal Bank of Canada Building. Extra heavy cast iron soil pipe was used in some locations where the static pressure could not exceed 50 p.s.i.

Domestic Water Supply Systems

Domestic water supply is furnished by the city by means of two 8 in. services from University Street. Normally one service only is used. Water is stored in 500,000 gal. concrete tank located at track level. Tank is arranged in two sections to allow for cleaning and maintenance. Each sec-

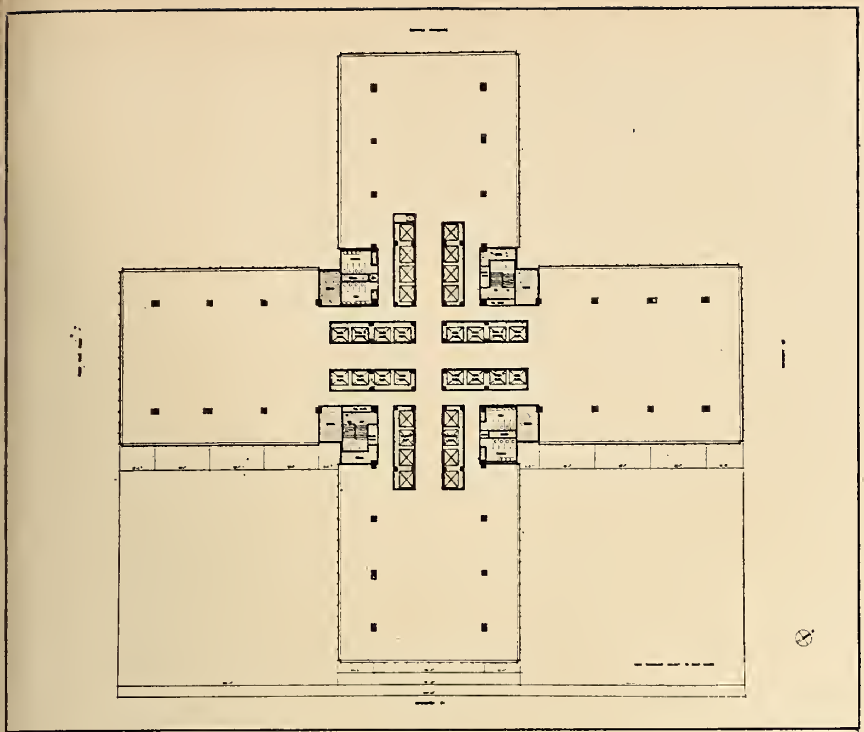


Fig. 4.

tion is divided into three compartments so that in case of failure of one section, a limited amount of water will spill into C.N.R. track area. Three 500 US gpm. vs. 350 p.s.i. and one 100 US gpm. vs. 350 p.s.i. take suction from this tank and serve the Royal Bank of Canada Building.

Cathcart Building is fed by three 250 US gpm. pumps vs. 125 p.s.i. direct electrically driven pumps, taking suction from 500,000 gal. reservoir. Domestic hot water tanks for Cathcart Building are steam heated and located on the 101 ft. levels.

The Royal Bank tower has three systems, a lower zone house tank, a high level zone house tank and a hydropneumatic system for the uppermost floors, observation tower and penthouses.

The low level house tank is located on the 27th floor. It has 17,000 U.S. gal. capacity, 10,000 for domestic water and 7000 for fire protection. It is divided in two sections to allow for cleaning and maintenance. Mains are overhead down feed run at the 23rd floor ceiling. Domestic water heaters are located in the Lower Mechanical Floor together with circulating return domestic hot water pumps.

The high level house tank is located on the Second Mechanical Penthouse 17,000 U.S. gal. similar to the lower tank. Distribution mains are run at ceiling of 41st and first mechanical penthouse. Domestic water heaters for the high level system and pumps are located on the 27th floor.

Upper high levels are served by two 400 and one 50 US gpm. vs. 60 p.s.i. hydropneumatic system. Water to cooling towers is metered.

Where water pressures exceed 60 p.s.i. static pressure, reducing assemblies are used.

A wet stack is provided in each wing of the Royal Bank of Canada Building for tenants' use with valved hot, cold and circulating return provided at each floor.

Royal Bank Quadrants, Lower Levels 92 ft., 101 ft., 110 ft., are fed directly from city service with separate hot water tanks. Hot water is preheated by a coil in the main condensate return receiver. The garage is provided with separate metered service. A hot and cold water loop at 101 ft. level ceiling is provided for the store areas and submeters will be installed later as required.

All water piping 4 in. and less is type K copper. Larger sizes are galvanized steel.

Fire Protection

With due regard for public safety, City, Insurance, Owner and C.N.R. requirements and interest an extensive system of fire protection is provided. The basic structure is fireproofed in accordance with City and insurance regulations. Detail studies were made of the track area as there are train loading platforms, diesel engines, electrically driven trains, catenary electric cables and connections to many buildings. The track area is ventilated to remove diesel fumes and the C.N.R. tunnel through Mount Royal connects on the north side of property. Track platforms are covered with a dry pipe sprinkler system. Areas at 92 ft., 101 ft., and 110 ft. levels below the Royal Bank Building are sprinklered. Track area is vented by means of 500 sq. ft. of stack area through the Cathcart Building. The site is fully protected with fire hose standpipe and hose systems. A fire road with access from St. Antoine Street is provided at track level. Facilities were made for firemen to drop hose from the street level to the tracks. Primary water supply is taken from University and Mansfield Streets by means of 8 in. connections with double bronze check valves and alarm valves. An 8 in. loop main is run at the lower levels and all alarm valves and hose connections for the lower levels are taken from this loop. Outside hydrants and high and low level pumper connections are provided at the 124 ft. level. Secondary water supply is provided by the 500,000 gal. reservoir. Two 2000 US gpm 100 p.s.i. pumps, one diesel and one electrically driven provide service for the lower areas. Pressure is maintained on the fire protection loop by means of a 25 US gpm vs 100 p.s.i. excess pressure pump. The electrical pump is started automatically on drop of water pressure. The diesel driven pump is started manually.

The Royal Bank Building is protected with fire hose standpipes and hose stations in cabinets and extinguishers. The standpipes are located in the core area with hose stations containing 1½ in. hose connected with reducer to 2½ in. valve. Orifices as required to limit the pressure on the 1½ in. first aid hose are installed. Primary water for the Royal Bank of Canada tower is provided by the two 17,000 gal. previously mentioned water tanks of which 7000 gal. is reserved for fire protection. Secondary water is taken from the reservoir at track level. Two 750 US gpm vs 350 p.s.i. fire pumps, one electric driven with variable speed motor and one diesel driven are provided. Pumps are manually operated from a signal system with stations located at each standpipe on every floor.

A coded electrical system supervises the fire protection system and senses and alarms on punch registers located in the lobby and site control office in the penthouse of the Royal Bank Building. A site fire brigade will be on duty at all times.

Heating, Ventilation and Air-conditioning Systems

The construction of the PVM project necessitated a ventilation sys-

tem for the C.N.R. track area below as it is intended to use diesel engines. Supply air is drawn from Lagauchetiers Street through a system of ductwork exhausting the track area and discharging to stacks which serve as fire vents in emergencies to the roof of the Cathcart Building. These systems were furnished and installed by C.N.R. and their consultants in co-ordination with PVM architects and engineers.

Ventilation of the garage and storage areas is provided by drawing in outside air through filters and heating coils and exhausting it to the roof of the Cathcart Building. The city recommendations for garage areas are that the carbon monoxide concentration does not exceed 150 ppm. for areas where people remain in the area for short periods of time only, and 100 ppm. where people remain in the area for extended periods of time. From our experience with similar types of garage areas, four to six air changes per hour of ½ to ¾ cfm/sq. ft. are sufficient for meeting the city requirements. Provision is made to allow recirculation of air for heating at night time in garage areas which are not being used. Sampling of carbon monoxide will be done to ensure criteria being met.

The ramp connecting Cathcart Street to the Garage, C.N.R. Station and Queen Elizabeth Hotel is mechanically ventilated with supply and exhaust air. The entrances to the ramp and truck dock where doors will be open for long periods of time are heated and protected with air curtains.

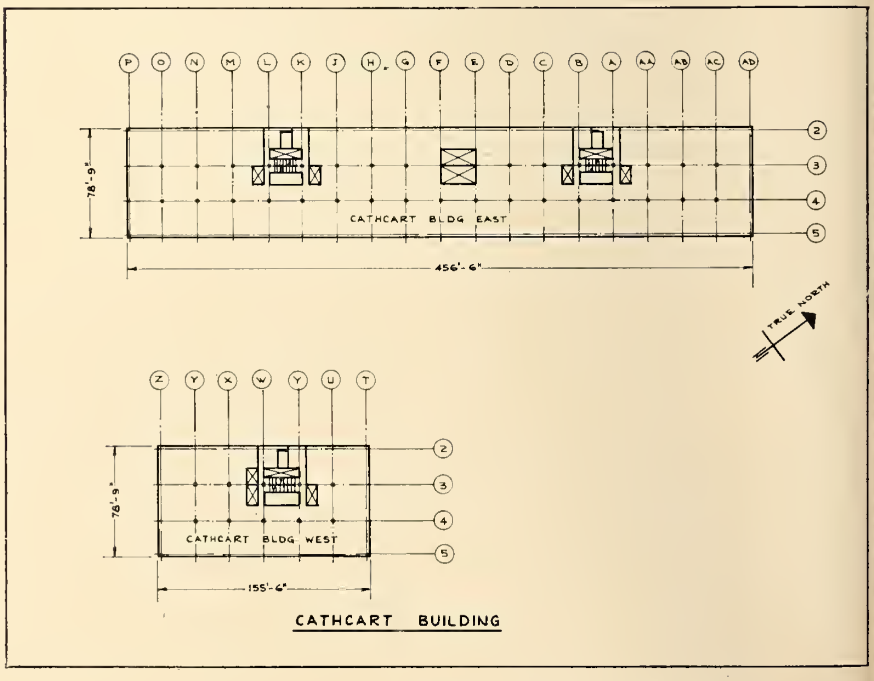
Miscellaneous supply and exhaust systems are provided for transformer rooms, diesel emergency generator, paint shop, pump and fan rooms exhausting to the roof of the Cathcart Building.

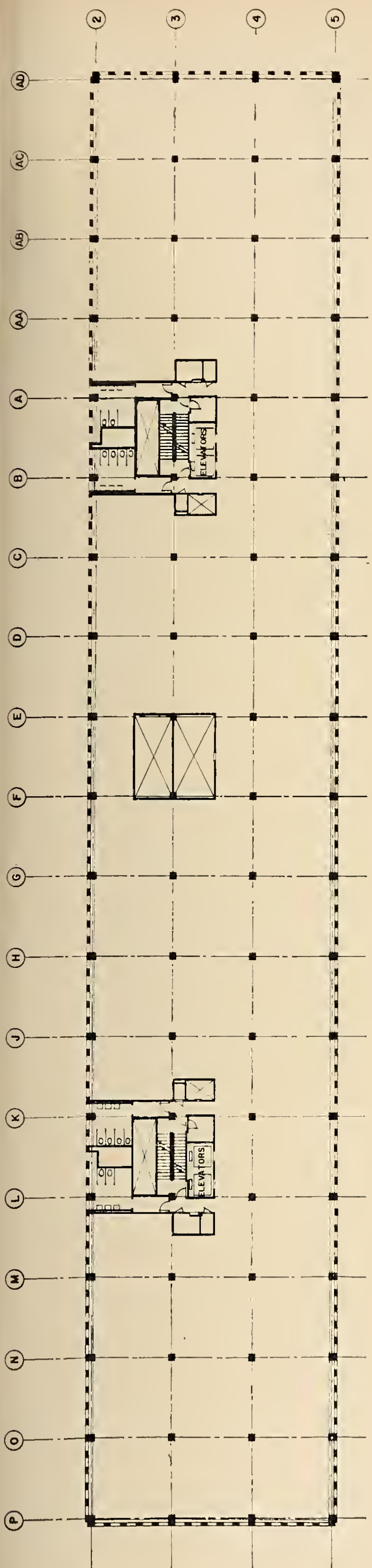
The Shopping Promenade is air-conditioned. Two cooling towers, each with a capacity of 1800 US gpm 95°, 85°, 75° F are provided at the roof of the Cathcart Building. Condenser water, steam and air is provided by the owner, and each store will have separate fan coil compressor units. The theatre and restaurant will be air-conditioned from the owner's Cathcart Street refrigeration plant located at track level. The restaurant will be exhausted to atmosphere at the Lower Mechanical Floor.

The Royal Bank of Canada Quadrants, retail stores below the Quadrants and Royal Bank Building are completely air-conditioned to maintain comfort summer and winter conditions. Each Bank Quadrant contains two fan rooms containing high efficiency dry type filters, heating and cooling coils, supply and return fans. Outside air is taken from the soffit below the Quadrants and exhaust air is discharged through the soffit area. Air is supplied to each dome in the ceiling to ensure no accumulation of smoke or stagnant air. In the Quadrant with the cafeteria and kitchen, air is supplied to the cafeteria and through a perforated ceiling in the kitchen, and exhausted out through hoods with ⅛ in. steel welded duct insulated with 2 in. magnesia and discharged to atmosphere at the Lower Mechanical Floor. Retail store below the Royal Bank of Canada Building at plaza level will have individual fan coil units with return fans.

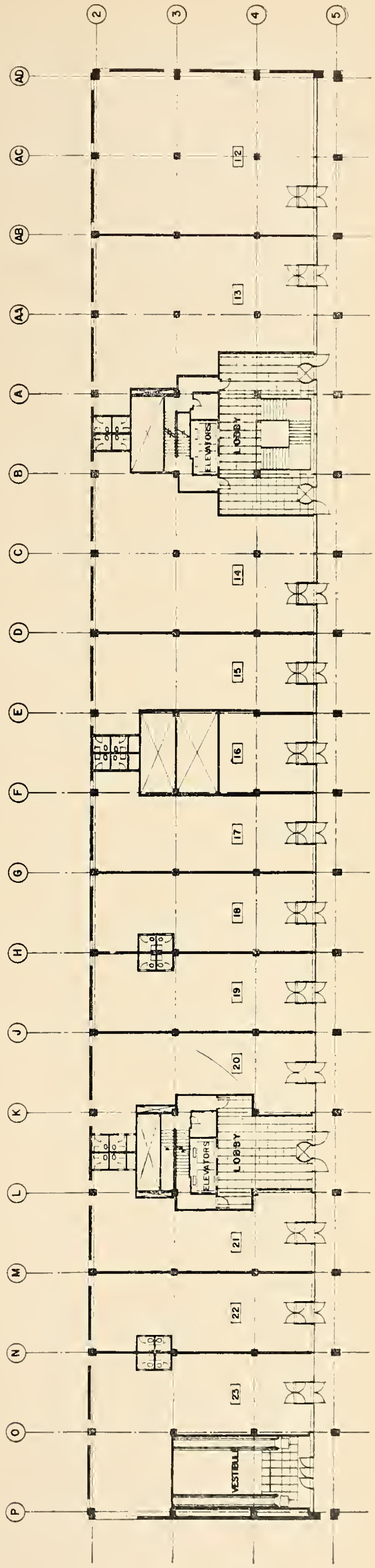
Extensive preliminary studies were made on various methods of providing air-conditioning for the Royal Bank Building. Methods considered were dual duct, all air underfloor system, individual fan coils on each floor, high medium and low pressure air distribution systems and induction windows units. Alternate machine spaces at the bottom, top and intermediate floors were considered. Various distribution system for air and water both with horizontal and vertical ducts and piping were analyzed. It was finally decided to provide maximum flexibility for leasing, and thus machine rooms were created at the top and bottom with no intermediate full machine floors (only minimum essential miscellaneous spaces for elevator machinery and water tanks). Main air and water risers are located in the core with horizontal mains on each floor. The building is essentially split in two sections, the lower machine floor serving the bottom 20 floors and the upper penthouses serving the top 20 floors. Studies and tests were made on the use and economics of single glass vs double glass. From the results it was finally decided that single glass would be satisfactory and fulfill the necessary requirements with an induction system and unit under each window. The induction unit enclosure is 1 ft. high and with 5 ft. x 7 ft. window modules large clear glass areas providing an unobstructed view of the city is made available to the occupants. Underwindow unit piping is so arranged to permit easy relocation of control valves to suit the partitions. Induction units are installed with thermostats and control valves to suit tenant's requirements. The peripheral area extends back 15 ft. from the wall. Tests were conducted at Penn State University on the curtain wall and glass with induction units to ascertain the limits of humidity control and operating performance of the assembly. The interior system of each wing has a medium pressure air distribution riser in the core and a branch with pressure reducing assembly, sound trap and steam reheat coil on the supply and a sound trap on each return for each wing. The ceiling space is used in most cases as a return plenum with connections to the riser in the core. The peripheral system was completely installed with the base building with valves and thermostats arranged to suit the tenants. Interior ductwork for the base building terminated at the core with p.r.v. assembly and sound traps and was extended to suit individual ten-

Fig. 5.





TYPICAL FLOOR



PLAZA LEVEL

Fig. 6.

ant requirements. The main air handling assemblies are located in the Lower Mechanical Floor and first and second Mechanical Penthouses. Primary air supply consists of 16 air handling assemblies two units per wing per 20 floors 23,400 c.f.m. each. Interior air is supplied from eight air handling assemblies 80 to 92,000 c.f.m. each, one per wing per 20 floors with return fans. Electrostatic agglomerator filters are used throughout. To minimize stack effect and freezing of coils on the Lower Mechanical Floor the air intakes have garage type doors to tightly close off outside air. Exhaust systems are provided for miscellaneous tenant requirements, dry core transformer rooms and toilet rooms. Elevator rooms have individual fan-coil recirculating systems located in the space for providing cooling. Lobbies are conditioned with fan coil units in the Lower Mechanical Floor and lobby. Air is supplied for heating through the mullions for the windows and special heating is provided for the doors. Miscellaneous systems for owner's Locker and Service Rooms and Observation Tower are located in the first Mechanical Penthouse.

Chilled water for the Royal Bank Building, Bank Quadrants, Retail Stores at plaza level below the Quadrants, Observation Tower, lobbies and elevators is supplied from the refrigeration room located in the west wing of the Second Mechanical Penthouse. Cooling towers are located on north wing of the First Mechanical Penthouse. Three 2000 ton totalling 6000 tons hermetic machines furnish chilled water at 42°F. Motors are 2300V/3/-60. A three cell cooling tower 18,200 U.S. gpm 95°F, 85°F, 75°F is provided with one cell winterized. Five condenser water pumps rated at 3600 U.S. gpm. vs 108 ft. head with 125 hp. 550/3/60 and five primary water pumps rated at 2500 U.S. gpm vs 125 foot head with 100 hp. 530/3/60 1750 r.p.m. motors serve for the refrigeration cycle. Two secondary water steam converters and three pumps for perimeter heating are provided in the second Mechanical Penthouse and similarly for the Lower Mechanical Floor. Pumps are rated at 2100 U.S. gpm. vs. 88 ft. with 75 hp. 550/3/60 1750 r.p.m. motors. To eliminate the high static head on the induction unit systems on the lower 20 floors of the tower, two chilled water to water heat exchangers each rated at 2100 U.S. gpm 53 to 57°F are provided.

As many tenants have requirements for air conditioning on 24 hour per day basis the year around, fan-coil-compressor packaged units are utilized as required and the owner has provided a winterized 200 ton condenser water system with risers through the tower.

The Cathcart Street Building is comfort air conditioned with an induction system on the periphery. There is a unit for each window. The air and water system for this building is more conventional utilizing horizontal mains and vertical risers. Fan coil equipment, convectors and secondary water pumps are located in the penthouses on the roof. Refrigeration machine is 540 tons hermetic 550/3/60 located at track level. A 400 ton hermetic machine located at track level serves the restaurant and theatre and is cross connected to the tower system to serve night or winterized loads. Stores at plaza level of the Cathcart Street Building will have fan-coil-compressor units, and the owner will provide cooling tower services to units. Acid and polyphosphate water treatment is provided for all cooling towers.

Controls

Pneumatic controls are used throughout the project with transmission of actual temperatures and continuous indication of temperatures at the central control panel. Individual fan coil units have local control panels as required. Central control panels are located in the Garage and Building Superintendent's Office on the second Mechanical Penthouse. Fans and pumps can be stopped and started from this point. All alarms are centralized on 96 point annunciator panel. Critical temperatures can be remotely readjusted. Steam flows and consumption, water flow and electrical power are recorded on the control panel.

Vibration Control

Vibration and noise control for the project was carefully checked, and the recommendations of Messrs. Bolt, Beranek and Newman, acoustical consultants followed. To this end care was exercised in the selection of equipment. Ductwork is lined as required. Pumps and fans are mounted on concrete bases with spring isolators. Piping is hung with spring hangers and fans have flexible connections on duckwork. Pumps will have flexible connections as required.

Electrical Services

Hydro service is supplied to the Site from 12 kv. 3/60 service from the Dorchester Boulevard sub-station. The incoming service feeders come from University Street and drop to the main switch and metering board at the 69 ft. level. Twelve kv. feeders rise to the Lower Mechanical Floor of the Royal Bank Building and to the second Mechanical Penthouse where they feed two banks of transformers 3-1666 kva. 12 kv. 550/3/60 one set for owner and one for tenants in each main sub-station. 550/3/60 feeders serve the Royal Bank Building floors and two 75 kv. A dry core transformers, 550/120/208/3/60 provide tenant service at each floor. Facilities for metering each tenant are provided. Feeders also rise express to feed the transformers for the refrigeration machines in the second Mechanical Penthouse 12 kv./2300 v. 2000 kv. A each. Sub-stations are provided for the Lower Levels, Garage and Cathcart Building 12 kv./550 with dry core 550/120/208 as required. The system had to be so arranged to provide flexibility for metering of owner's services and large and small tenants. Emergency power for the lower levels is provided by a 500 kv. A diesel generator and for the Royal Bank Building by the 1000 kv. A turbo-generator located in the second Mechanical Penthouse. A 200 line Owner's internal telephone system, fire protection system and strap key intercommunication for fire pumps has been provided. Total connected load is estimated at 36,000 kv. A.

General

From the foregoing article it is readily seen that the development of a project as complex as this one requires the close co-operation of the owner and tenants, the architect, structural, mechanical and electrical engineers, contractors, sub-contractors and suppliers as well as C.N.R. staff, city authorities and insurance underwriters and other agents. Plans and specifications have to be produced, men, equipment and material scheduled and expedited and the work supervised, tested and operated. Acknowledgement is made to the many people who participated in this project, and their fine co-operation to make it all possible.

Developers: Webb & Knapp (Canada) Ltd.; Construction Manager: Q. L. Carlson; Architects & Planners: I. M. Pei & Associates; Partner in Charge: H. N. Cobb; Associate Architects: Affleck, Desbarats, Dimakopoulos, Lebensold, Michaud & Sise; Consulting Mechanical & Electrical Engineers: Jas. Keith & Associates; Consultants: Cosentini Associates; Structural Engineers: Brett, Ouellette & Blauer; Consultants: Severud-Elstad-Krueger Associates; General Contractors: Foundation Company of Canada Limited; HVAC Sub-contractor: John Colford Contracting Co. Ltd., Kirby Saunders (Canada) Ltd.; Electrical Sub-contractor: Canadian Comstock Company Limited.

ENGINEERS AND THE CANADIAN ECONOMY

J. P. Francis,
Director, Economics and Research Branch,
Department of Labour, Ottawa.

The future will see an increasing use of technicians on subprofessional work now being done by engineers. And as a greater number of bright people start to come from university courses oriented to the needs of business and commerce, engineers will find themselves in intense competition with such people. Both of these pressures will generate further basic changes in the engineering profession.

IN 150 YEARS or so when historians are searching for a word or a phrase to describe the 20th Century, I often think that they may well come up with the term "the explosive age". Everything seems to be exploding these days. In addition to nuclear explosions, we have population explosions, explosions of national consciousness, intellectual explosions, and, of course, more specifically, technological explosions.

It is the latter kind of explosion, the scientific or perhaps more accurately the technological explosion we are experiencing at present, about which I am going to be concerned today. I would like to explore how modern technology through its impact on economic development in Canada is affecting, both quantitatively and qualitatively, our needs for one kind of high talent manpower, engineers. How rapidly have engineering manpower needs been growing in this country? What aspects of our economic development have created this expansion? How well have the needs been met? Are the engineering manpower requirements of this country likely to be much different in future and, if so, what kinds of problems are apt to emerge?

Far too often, it seems to me, the question of our needs for engineering manpower on this continent have been considered in terms of how we compare with the Soviet Union. In recent years, the discovery that the Soviet Union is graduating many more engineers per year than the United States and Canada, which in turn are graduating many more than Western Europe, has caused considerable panic. The most recent informa-

tion on this point is provided by an 850-point report on Soviet education by Professor Nicholas DeWitt, published by the National Science Foundation in the United States.

A question which naturally comes into one's mind is, if North America is in such bad shape for lack of engineers, how is Western Europe, with a great many fewer engineers, able to carry on at all?

Part of the answer is that Western Europe uses its university-trained engineers with much greater economy than we do, providing them with much more assistance in the form of highly-trained technicians and skilled labor. If we have a shortage of engineers, the reason is partly that many of our engineers are employed at sub-professional and non-engineering tasks which do not make reasonable use of their technical knowledge.

I am not going to undertake to tell Khrushchev that he is training too many engineers. But the correct criterion of the number of engineers to be trained in the United States and Canada is not the number being trained in the Soviet Union, but the number that can be usefully absorbed into the economies of Canada and the United States. If we train too many engineers we will have too few of something else.

Furthermore, in the competition in engineering which North America seems to be conducting with the Soviet Union, the critical point is not the quantity of engineers but their quality. The real menace is not that the Soviet Union may soon have more engineers than we do, but that its best engineers may be better than our best.

Let us take a look first, then, at how the economic development occurring in Canada over the last three decades has, in fact, affected engineering manpower needs. In doing this, I want to separate these decades into two periods, 1931 to 1951 and 1951 to 1961, because the picture changed quite dramatically about ten years ago. In addition, I want to distinguish between the effects of three basic factors which determine the economy's requirements for engineers.

The first of these is simply the growth in the total size of the economy and the working force, and this I shall refer to as the labor force growth factor. The second is the changing industrial structure of the economy—if industries which employ engineers are growing faster than those which do not, then obviously total needs for engineers will increase although proportionately no single industry will be employing any more—and this I will call changing industrial structure. The last factor deals with changes in the relative numerical importance of engineers in individual industries. An increase in the number of engineers needed by the economy due to the fact that various industries are employing a greater proportion of them, I will label occupational composition changes.

From 1931 to 1951 the Canadian labor force grew by 33%, and the total number of engineers increased by 99%—three times as fast. Why did engineering manpower requirements increase so much faster than the labor force over this period? In terms of the factors which I have just listed, the main reason was the changing industrial structure of the economy. The proportion of engineers employed in various industries changed to a very small degree. We can summarize the 99% growth in engineering manpower needs in this country over this period as follows: one-third due to labor force growth, almost two-thirds due to the changing industrial structure of the economy (many of the industries employing engineers were the fastest growing ones), and a negligible fraction due to occupational composition changes.

Now this analysis, I feel, is helpful in understanding the dynamics of engineering manpower demands over this period. It shows that while needs for engineers increased rapidly, this was not due to technical innovations within industries which resulted in more engineers being required by these industries in relation to other kinds of manpower. Rather, the major determinant was the changing industrial character of the economy, due principally to natural resource development (mineral and power resources, for example) and the growth of secondary manufacturing industry in response to the almost insatiable domestic and world-wide demands which existed in the first 10 years after the Second World War. If these points are not clearly understood then subsequent events become confusing and open to misleading interpretations.

Now let me turn to the most recent decade. From 1951 until 1961 the number of engineers in Canada increased by about 80%, totalling approximately 49,000 in the latter year on the basis of estimates prepared by the Department of Labour. This was a faster rate of growth than that of the previous two decades. During this same decade, 1951 to 1961, the labor force increased by 25% so that engineers were growing in number slightly more than three times as fast as the labor force.

What contribution did the three growth factors mentioned earlier make in the past 10 years? Their effects can be summarized again as follows: slightly less than one-fourth was due to labor force growth, a negligible amount was due to changing industrial structure, and more than two-thirds was the result of changing occupational composition. This means that during the past 10 years, technological and other changes within industries have resulted in significant increases in the proportion of engineers being employed, in certain industries at least. This is in sharp contrast to the comparable picture in the previous two decades.

What does this rather startling change mean? It means that the nature of our economic development has changed very considerably over the last decade and this has reshaped the character of the requirements being generated for engineers. Instead of these needs being created by the sheer growth of the manufacturing and other industries which employ engineers, a few of these and some other industries have more recently been employing engineers to a much greater extent than heretofore.

What are the industries which have been hiring relatively greater numbers of engineers, and what have these engineers been doing? The main ones are government, the chemical manufacturing industry, and the electrical, electronic and power industries. It is interesting that these sectors of the economy represent two major technological fields, electronics and chemistry, whose impact on Canadian economic development has been tremendous, and whose importance for our future economic growth is crucial. In government, they also include the sector of the economy where most research and development work is done in Canada, but as well where a considerable amount of construction work is planned and supervised.

Another important feature of the past decade has been the tremendous increase in firms and individuals offering professional engineering services—what is more popularly known as consulting. The greater availability of these services has made it possible for many medium-size and smaller firms to purchase top-notch engineering advice and assistance on a contract or fee basis which they could not afford to obtain by developing engineering departments of their own. There has evidently been some tendency as well for larger firms to contract out their engineering work to consulting organizations.

This relative shift of engineering work, in the technical sense of that

term, from the large corporation to the specialized professional service firm is very significant—it has probably lowered the unit cost of such services in the economy as a whole and at the same time has brought modern technology to a greater extent within the reach of many more companies and organizations. For a relatively small country like Canada, this is crucial.

So far we have been talking about the factors determining engineering manpower requirements and how these have been changing during the past three decades. The question still remains, however, whether we have too many engineers, not enough, or just about the right number? This question can be put in a slightly different way; are we spending too little, or too much, or just enough on the education and training of engineers?

Recently some economists have approached this question by regarding educational expenditures as a form of investment and by trying to calculate the financial return received by college graduates on the money invested in their college education. The conclusions reached to date, as far as the United States is concerned, appear to indicate that the rate of return to investment in college education is about equal to the rate of return prevailing for investment in general, when this latter rate includes some allowance for risk, corporate income tax, etc. Consequently, it would appear that in recent years investment in college education in the United States has been at about the right level.

There is a serious problem inherent in this approach because of the large proportion of the return to expenditures on college education which cannot be measured in monetary terms. This proportion of the return includes non-measurable returns to both the community as a whole as well as to the individual.

In regard to non-measurable returns to the community as a whole, I cannot express the point better than did Alfred Marshall, the great English economist of the nineteenth century:

> "The wisdom of expending public and private funds on education is not to be measured by its direct fruits alone. It will be profitable as a mere investment, to give the masses of the people much greater opportunities than they can generally avail themselves of. For by this means many, who would have died unknown, are enabled to get the start needed for bringing out their latent abilities. And the economic value of one great industrial genius is sufficient to cover the expenses of the education of a whole town; for one new idea, such as Bessemer's chief invention, adds as much to England's productive power as the labor of a hundred thousand men. Less direct, but not less in importance, is the aid given to production by medical discoveries such as those of Jenner or Pasteur, which increase our health and working power; and again by scientific work such as that of mathematics or biology, even though many generations may pass away before it bears visible fruit in greater material well-being. All that is spent during many years in opening the means of higher education to the masses would be well paid for if it called out one more Newton or Darwin, Shakespeare or Beethoven."

In view of the high productive potential of new ideas, and in view of the fact that many highly intelligent people are among those not yet getting a higher education, the results which might be reaped from sending an additional 10,000 Canadians to college each year cannot be precisely estimated; it would be a gamble in which the possible losses were strictly limited, while no limit could be set to the possible winnings.

Non-measurable returns to the individual are returns from what is sometimes called "consumption education". These returns come chiefly as sophisticated forms of enjoyment.

It must be delightful, for example, to be able to laugh at the jokes of Aristophanes, when and if you hear him acted in the original Greek. A man who can do that is a man of great culture; he is also one up on the rest of the audience.

Consumption education does not have to be at the university level. Suppose a man has an excellent cook who happens to be illiterate. He teaches her to read. As a result, she reads "Dracula" and thus becomes a woman of broader culture and wider interests, but her productivity as a cook is not improved. In fact, she entirely ceases to make her previously celebrated blood puddings.

One thinks chiefly of literary studies in connection with consumption education. But any subject can serve as consumption education, provided that the knowledge is not used for production. A bishop might take a course in electrical engineering and use the knowledge only to build a model electric railway in his rumpus room. In fact, practically all education contains a certain element of consumption; however serious one's purpose in taking a course, one can hardly avoid learning some things that are merely interesting or amusing.

Despite these difficulties, this approach offers considerable promise as one of the analytical tools needed to help us form an economically sound judgment about the amount of expenditures being made in the country on different kinds of education and training. It would seem to be particularly appropriate as a means of assessing expenditures on those kinds of education which are clearly a preparation for some occupational field of employment. One might select types of education, such as engineering, which are clearly oriented towards specific occupations and attempt to estimate the relative returns on the investment involved. The difficulty at present, of course, is the lack of statistical data in sufficient detail and over a long enough period. One would also have to be careful about drawing conclusions because there might still be important non-measurable returns. I might mention, however, that some work along this line is being initiated in the Department of Labour.

You may wonder why I have spent some time talking about education as an investment, and the problems of measuring the return on that investment. I have not lost my way, nor digressed to an irrelevant matter. I am trying to underline the fact that when we develop facilities to produce engineers, or any other kind of highly trained manpower, we are allocating scarce resources which can be used in other ways. In making such allocations, therefore, we need to consider whether an expenditure of say $25 million on engineering education might not yield a greater return if put into the education and training of technicians, or of scientists, or even of economists. It is not enough here to rely on opinion; opinions are cheap. We need to know the needs of our economy when, as the saying goes, people have to put their money where their mouth is, and when their economic survival depends on how they spend their money.

So far I have been talking about trends in engineering manpower requirements, and indicating one of the ways in which we can, from an economic point of view, make a judgment about whether we are producing too many or not enough engineers in relation to the real needs of the economy. My analysis of requirements suggested that an important change

has taken place over the last decade in the nature of the economy's needs for engineering manpower, and that this change was primarily the result of the growing importance of technology in economic development and progress. My remarks about investment in education, and in engineering education in particular, indicated a need for some critical analysis in terms of the returns which the economy is offering for this investment in relation to other kinds of alternative uses.

I would now like to approach the question of the adequacy of our current engineering manpower resources from another direction, by examining how engineers are being utilized in this country. To do this it will be helpful, I think, to compare the kind of work being done by engineers in Canada with that carried out by similar personnel in the United States. In doing this, I will rely on data produced by our respective Departments of Labour, and such data will refer only to engineers employed in industry—engineering employment in government and educational institutions will be excluded. The data used for Canada refer to 1959, while those for the United States apply to 1960.

In Canada, about 6% of all our engineers in industry were employed in 1959 primarily on research and development activities; the comparable figure for the United States in 1960 was 29%. In Canada, 47% of our engineers were engaged on production and directly related kinds of work; the percentage in this type of work in the United States was 41. In Canada, 28% of our engineers were performing administrative and managerial functions, while in the United States the comparable figure was 14%. There is a residual group of 17% in Canada, and 15% in the United States, who were performing a range of other functions including selling, instructing, and a variety of financial, personnel, and related activities.

Now these figures, of course, are subject to all the specific incomparabilities one must expect when using data from different sources, but they undoubtedly reflect the main features of the picture in the two countries. They show a very different situation in the kinds of work being done by engineers in Canada as compared with the United States, and this in turn reflects basic differences in the needs being generated by the two economies for engineers. It is important to emphasize these differences because we frequently have the unfolding picture of engineering manpower needs in the United States translated to this country and used as a basis for suggestions as to how many and what kinds of engineers we should be producing. In part, I am convinced, it is this kind of analysis which until recently led to the serious lack of balance in our educational investment as between facilities to produce engineers and those needed to turn out technicians. This imbalance is now being rectified.

I would now like to use the preceding analysis as a basis for some concluding observations. The emerging needs for engineering manpower in this country today are more directly related to technological developments in industry than has ever been the case before, and in future this link will become an even closer one. Research and development activities in industry and related highly technical work are, in fact, going to determine to a significant degree our economic future. In the face of this trend, we find that the vast majority of engineers now being produced in this country are still entering the work world with only an undergraduate engineering degree. In 1961, for example, out of every 100 undergraduaate and postgraduate degrees obtained in the engineering field in Canadian universities, less than one was at the doctoral level. Apart from the new supply of engineers, we are well into this new trend with the vast majority of engineers already employed having no more than an undergraduate education and with practically no facilities whereby such people can raise their basic academic qualifications.

The emerging requirement for a more highly trained kind of engineer is already posing a real problem for Canada. Postgraduate training is expensive and we cannot expect to develop facilities at this level which can produce all kinds of highly trained manpower. We will need to make some difficult choices, and these will have to be based on coldly realistic appraisal of the kinds of postgraduate training which are most suitable to our requirements.

Many of the engineers engaged on production and related tasks in this country are undoubtedly doing subprofessional work. This has not been too serious a matter in the past when technicians and related kinds of workers were in scarce supply. In future, however, we will be turning out such supporting personnel in increasing numbers and employers will find it cheaper and more productive to use them for that kind of work. This is going to require some difficult adjustments for those engineers now under-employed in technician jobs. They will find newly trained technicians being preferred by employers, and at the same time probably discover that their technical qualifications leave something to be desired in relation to the growing kinds of professional engineering jobs. Here is a situation fraught with economic and social difficulties.

Another possible future problem concerns those engineers now engaged in work which is largely of an administrative nature. We may find to an increasing degree that other types of higher education (business administration, economics, management education on top of a liberal arts course) create a product which is more useful and less costly for employers in relation to administrative and management jobs.

Business management today depends to an increasing degree on the efficient use not only of technology but also of manpower and financial resources, as well as the latest organizational techniques and a myriad of promotional and public relations tools. To a considerable degree, when engineers are employed in these kinds of jobs they are being employed as bright people with considerable general potential. It may well be that the return on the higher educational investment involved is increased when bright people with potential are produced from a range of other university courses than engineering.

In summary, my analysis suggests that there are some difficult problems ahead for engineers in the light of the kind of economic development we are already experiencing and will likely continue to see. Technically, engineers will need to be more highly educated than at present. Many now employed in non-technical jobs, or in positions where new kinds of specialized education may become more appropriate, will find themselves in a competitive situation in which they are at a disadvantage. For technician jobs, engineers cannot really compete with those who have been trained more directly for such work; the engineer is too expensive. Business management, personnel, financial and promotional specialists, providing they are bright people with potential, will in many cases be more suitable for management jobs than engineers.

These developments, if my speculations are near the mark at all, will change the engineering profession considerably as well as the sort of educational facilities being developed to produce engineers. Attention is already being given to these problems by some people, but a much more realistic and serious consideration is necessary. EIC

The Production and Use of an Animated Film

FOR TEACHING KINEMATICS

G. F. Pearce, M.E.I.C.,
Asst. Professor of Mechanical Engineering, University of Waterloo

IN MANY areas of engineering significant extensions of knowledge have occurred during the past decade. These pose a problem for the teacher of engineering; viz., how to get the student to absorb more material in the allotted time. One solution to the problem is to use more effective visual aids, which give the student such a clear conception of the elementary principles that he can progress to the advanced work more rapidly.

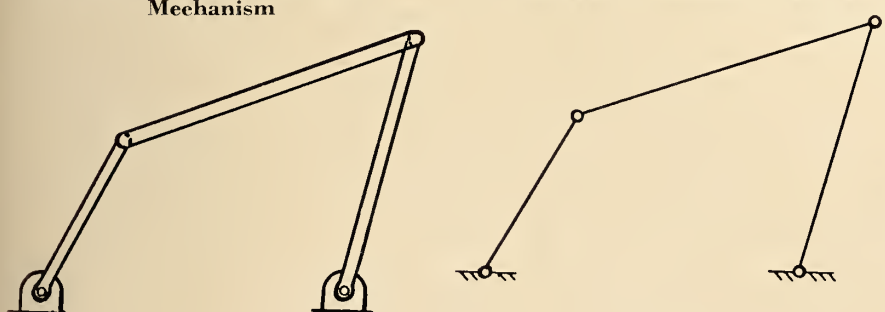
In the general field of kinematics of mechanisms, visual aids are particularly useful. These aids usually fall into two categories; actual models of mechanisms and line drawings. The models serve to introduce the student to the motion of simple, basic mechanisms such as gears, cams, and linkages. For students with a limited previous exposure to mechanisms, these operating models are very instructive. The so-called "kinematic" line drawings are widely used in the design and analysis of mechanisms. A sketch of a mechanism and its equivalent kinematic line drawing are shown in Fig. 1. In the kinematic line drawing the individual members are replaced by lines representing their kinematic equivalent.

The model is used mainly to show the method of operation and relationship between the members of a mechanism. The quantitative determination of displacement, velocity and acceleration values are determined by various methods from an analysis based on the kinematic line drawing. The usual graphical procedures result in values of pertinent velocities and accelerations for one particular position or phase of the mechanism. At this stage, the student is cautioned that these values are a function of the phase of the mechanism and will vary throughout the operating cycle. This can be verified from an observation of the model, if available, but only in a qualitative manner. For a quantitative verification, it is necessary to repeat the graphical procedure at several different positions of the mechanism. This is a tedious procedure and it is felt that the student would be better employed in more advanced work on mechanisms if the concept of phase dependency could be brought home more vividly. It is necessary that he retain this awareness without having to spend a great deal of time in analysing some particular mechanism at many different phase positions. This is the basis for the need of a more effective visual aid in teaching velocity and acceleration relationships in mechanisms. The animated film appears to supply an answer to this need.

A four-bar linkage was chosen as the particular mechanism to animate. This mechanism is basic in the study of kinematics, it is widely used for purposes of illustration in textbooks, and it is easily drawn. In order to explain how an animated film was used to illustrate the velocity and acceleration in such a mechanism, it will be necessary to outline the graphical method of determining these quantities. This method, explained in most texts on kinematics of machines, is usually called the vector polygon or image method. As illustrated in Fig. 2, a polygon (in this case a triangle) can be drawn to represent the velocities of pertinent points in the mechanism. O' is called the origin or pole point, $O'P'$ is a vector representing the velocity of P. The magnitude of $O'P'$ is calculated from the basic relationship, $V = R\omega$, and its direction is perpendicular to O_1P. The line $O'Q'$ is a vector representing the velocity of Q and line $P'Q'$ represents the relative velocity of Q with respect to P. In a similar manner the acceleration polygon of Fig. 3 can be drawn. The magnitude of $O''P''$, the normal acceleration of P, can be calculated from the known input conditions and the direction is along PO_1. The magnitude of the normal acceleration of Q can be calculated from information from the velocity diagram and the direction is along QO_2. Similarly the relative normal acceleration of Q with respect to P can be calculated from data from the velocity diagram and its direction is along QP. The remaining tangential accelerations are determined from the graphical construction required to close the acceleration polygon.

The velocity and acceleration vector polygons show the magnitude and direction of these characteristics only for the particular phase position of the linkage shown. For any other position, these polygons change shape because they are, in part, dependent on the inclination of the links of the mechanism. This change in velocity and acceleration can be seen if a series of polygons at various phase

Fig. 1. (a) Sketch of a Four-Bar Mechanism (b) Equivalent Kinematic Drawing



(a) (b)

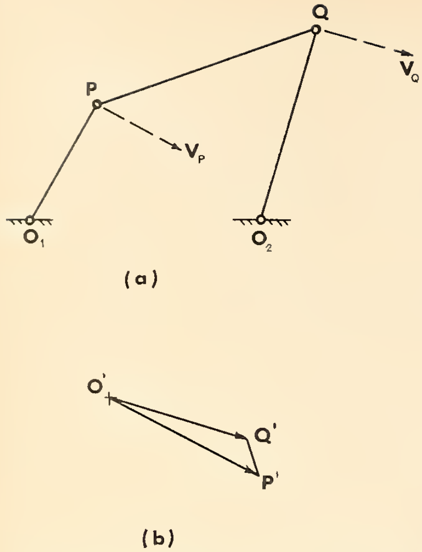


Fig. 2. (a) **Velocities in a Four-Bar Mechanism**
(b) **Velocity Polygon**

angles are constructed. When this series of drawings each showing the phase position or displacement, the velocity polygon, and the acceleration polygon, are viewed in proper sequence, the relationships are impressed on the student. The animated film is a method of presenting a succession of such drawings.

Film Production

An animated film consists of a large number of individual images which, when projected on a screen, provide an illusion of movement due to the phenomenon of persistence of vision. The individual images—called frames—are projected at a rate of 16 per second for silent films and 24 per second for sound films. The basic production process for an animated film is then simply to produce the required drawings and photograph them one by one in proper sequence. A strip of 16 mm film (enlarged) is shown in Fig. 4.

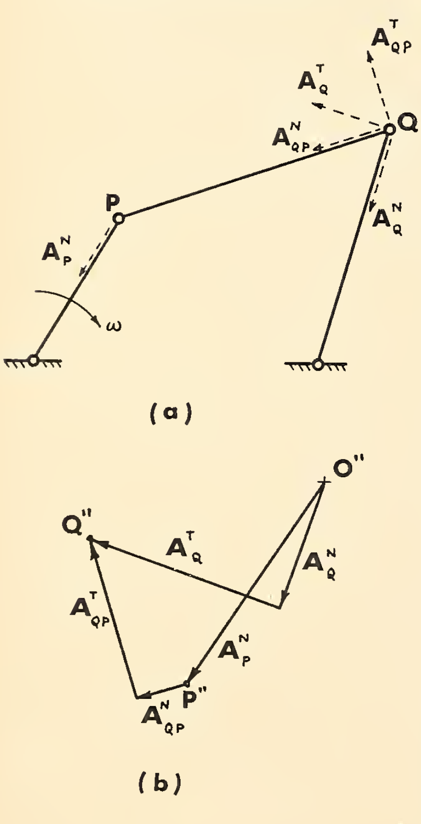
To obtain the proper sequence of drawings and suitable timing of the action so that it appears neither too fast nor too slow it is necessary to have some plan of production which is called a script. The script—usually illustrated with sketches—describes the action in broad terms. An example of the script suggested for this film is shown in Fig. 5. A more detailed script is then made out for each scene. An example of the script for a scene is shown in Fig. 6.

The actual production of the drawings is the next step. As there are a large number of individual drawings it is advisable to number each one with some sort of code so that it can be identified with a scene and its sequence in that scene. Since the drawings will be photographed in succession, each drawing must have a datum line which is fixed and is in exactly the same position on every drawing. If this is not done, it is obvious that the drawings will have some erratic relative motion which is not intended, when viewed.

In other words, the drawings must be in correct register, one with another. A means of achieving this is to use an animation desk which is fitted with register pegs. Such a desk is illustrated in Fig. 7. The desk has a ground glass insert with a low power lamp underneath so that several drawings can be viewed at one time to check the relative motion between them. Three-hole punched, plain, medium quality paper was found satisfactory for the drawings.

The number of frames required for each scene is determined by multiplying the desired viewing time in seconds by 16 for silent film or 24 for sound film. The number of drawings required depends on the particular animation. For example, when an explanation is being made, one appropriate drawing is photographed repeatedly while the narrator speaks. On the other hand, a separate drawing is required for each frame when animation is in progress. In this particular film it was decided that if the displacement drawings were made at 2° intervals of the driving crank, *OP*, a

Fig. 3. (a) **Accelerations in a Four-Bar Mechanism**
(b) **Acceleration Polygon**



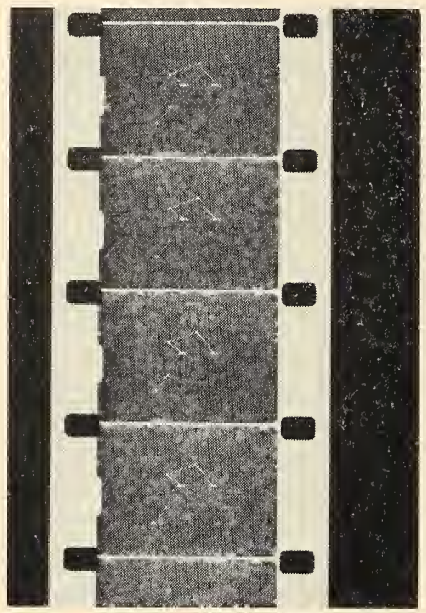


Fig. 4. **Sample Strip from Animated Film**

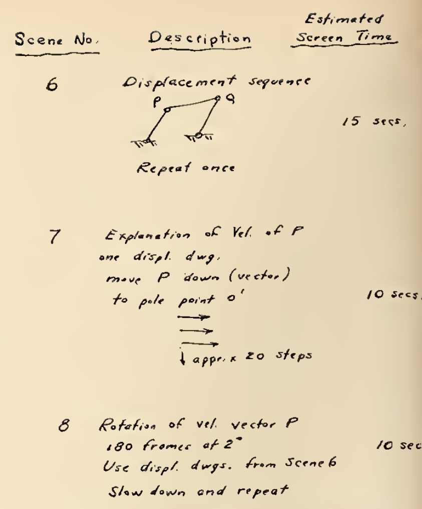
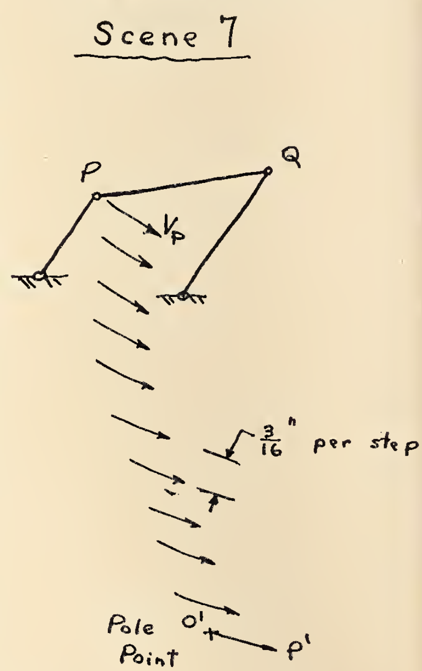


Fig. 5. **Excerpt from Suggested Script**

Fig. 6. **Details of Scene 7**



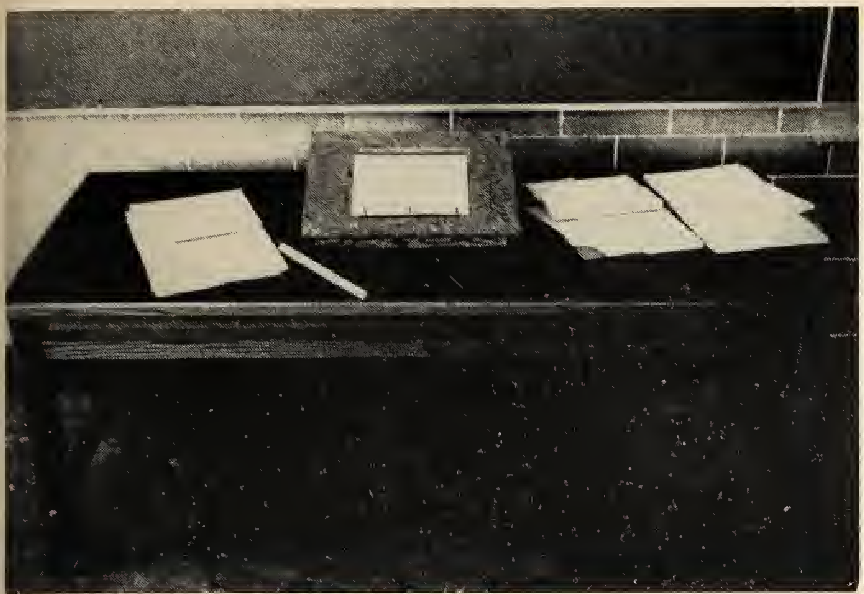


Fig. 7. Animation Desk

suitable viewing time would be obtained.

At 2° intervals, one rotation or cycle of the mechanism would require the construction of 180 separate displacement, velocity and acceleration diagrams. The construction of the displacement drawings was straightforward. The velocity polygons were relatively easily obtained by graphical methods. The acceleration polygon on the other hand required several measurements and calculations for each drawing. As this was considered too time-consuming and liable to error, it was decided to use a digital computer to calculate the accelerations.

An analytical solution for relative velocities and accelerations has been developed by G. H. Martin and M. F. Spotts[1]. For the notation shown in Fig. 8, the following expressions are given:

$$\dot{\theta}_3 = -\frac{r_2 \sin(\theta_2 - \theta_4)}{r_3 \sin(\theta_3 - \theta_4)}\dot{\theta}_2$$

$$\dot{\theta}_4 = \frac{r_2 \sin(\theta_2 - \theta_3)}{r_4 \sin(\theta_3 - \theta_4)}\dot{\theta}_2$$

$$\ddot{\theta}_3 = \frac{\dot{\theta}_3}{\dot{\theta}_2}\ddot{\theta}_2 - \frac{r_2\dot{\theta}_2^2 \cos(\theta_2 - \theta_4) + r_3\dot{\theta}_3^2 \cos(\theta_3 - \theta_4) + r_4\dot{\theta}_4^2}{r_3 \sin(\theta_3 - \theta_4)}$$

$$\ddot{\theta}_4 = \frac{\dot{\theta}_4}{\dot{\theta}_2}\ddot{\theta}_2 + \frac{r_2\dot{\theta}_2^2 \cos(\theta_3 - \theta_4) + r_3\dot{\theta}_3^2 + r_4\dot{\theta}_4^2 \cos(\theta_3 - \theta_4)}{r_4 \sin(\theta_3 - \theta_4)}$$

A computer program was made to solve the above equations and then perform simple multiplication to give the following accelerations:

$$A_Q^N = r_4\dot{\theta}_4^2$$

$$A_Q^T = r_4\ddot{\theta}_4$$

$$A_{QP}^N = r_3\dot{\theta}_3^2$$

$$A_{QP}^T = r_3\ddot{\theta}_3$$

The data supplied to the computer was $r_2 = 1$, $r_3 = 1.75$, $r_4 = 1.5$ and $\dot{\theta}_2 = 1$. In addition, values of θ_2, θ_3 and θ_4 were supplied at 2° intervals as measured on the displacement drawings. As a digital computer can turn out incorrect answers at a great rate, it is necessary to check sample values by some independent method such as the standard graphical procedure.

After the production of the required drawings, each drawing must be photographed in proper sequence. The arrangement of lights, camera, and drawing is shown in Fig. 9. The same animation desk is fastened rigidly to a frame which also supports the camera. Each drawing is placed in turn over the holes on the registration pins and photographed using the single frame exposure setting of the camera. Proper lighting is a matter of experimentation. For the arrangement shown, the following settings produced satisfactory results:

Lens setting: f 16; Lens to drawing distance: 25½ in.; Lights: No. 2 Photofloods—one on each side; Light to drawing distance: 22 in.; Film: Kodachrome Type A.

Usually some editing of the film as returned from the processor is necessary. Errors in timing can be rectified by cutting out unwanted sections or by rephotographing certain sequences.

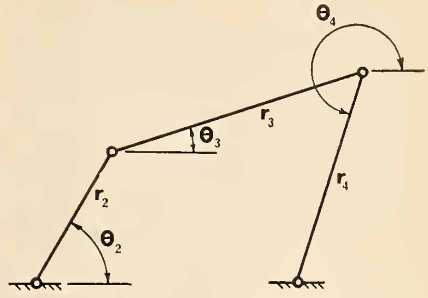


Fig. 8. Notation for Mathematical Expressions

This completes the description of the actual production of the film. The explanation of the operations is given in some detail so that those interested in the production of similar films may have an idea of the work involved. For this particular film some 828 separate drawings were made. This figure may appear high but it should be remembered that many drawings contained only three straight lines and all were very similar.

The film has been used during the course on kinematics at the University of Waterloo. No statistical proof of its effectiveness is available, however, student reaction has confirmed the author's opinion that the relationships intended were vividly portrayed. It appears that the basic concept has been firmly impressed on the students. It is considered therefore, that this is an effective visual aid. It is suggested that the same technique could be applied in other areas of engineering education.

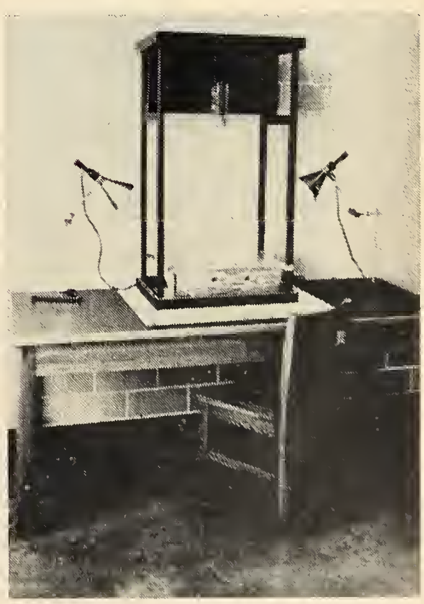
References

1. G. H. Martin and M. F. Spotts, **An Application of Complex Geometry to Relative Velocities and Accelerations in Mechanisms.** Transactions ASME 1957 Vol. 79, p. 687.

Bibliography

1. J. Halas and B. Privett, **How to Cartoon.** Focal Press, London and New York, 1958.

Fig. 9. Camera Stand



FOUNDATION FAILURE OF A SILO ON VARVED CLAY

W. J. Eden, M.E.I.C.
M. Bozozuk, M.E.I.C.
Research Officers, Soil Mechanics Section, Division of Building Research, National Research Council, Ottawa

THIS PAPER is a case record describing the bearing capacity failure of a farm silo near New Liskeard, Ont. The silo failed suddenly in July, 1961, the day following its first filling to capacity. The failure of this silo, which was founded on a considerable depth of normally consolidated varved clay, provided an opportunity to assess the applicability of bearing capacity theories to a highly stratified clay.

In September, 1961, a field investigation was carried out in which the undisturbed strength of the clay was measured with a field vane apparatus and samples taken with a thin-walled tube piston sampler for laboratory strength determinations. The results of the site investigation are presented and discussed with regard to the required bearing capacity.

The Structure

The cylindrical silo was constructed of precast concrete staves with a sheet aluminum dome roof. The staves were retained by steel tension hoops placed around the outside. The silo measured 20 ft. inside diameter by 50 ft. high and was founded on a concrete ring 22 ft. outside diameter by 18 ft. inside diameter. The ring extended from 1 ft. above grade to 4 ft. below grade. At grade level, four clay tiles passed through the concrete ring to drain off the excess silage juices. The foundation was a rough casting that provided good adhesion between the soil and the concrete. The soil retained by the concrete ring was left undisturbed.

The silo was located in the corner of a barnyard about 30 ft. from the corner of the barn. In preparation for paving the yard, about 1 ft. of soil had been removed from one side of the silo. This slight excavation extended from the barn to within 3 ft. of the silo.

The Failure

The silo was filled with grass silage from July 15 until July 23 at a variable rate due to poor harvest weather. It is believed that a significant portion of the full capacity load was applied on July 23. On the morning of July 24, one of the farm hands thought he noticed a slight tilt to the silo but not enough to be positive. By early afternoon the tilt was quite pronounced and it was decided to move the silage blower to safety from its

Fig. 1 (a) General view of collapsed silo.

Fig. 1 (b) Attitude of the silo base after failure.

position beside the silo. Before the blower could be pulled clear however, failure of the silo occurred. As it failed, the silo structure broke. Fig. 1(a) shows the failed structure. To salvage as much of the silage as possible, tarpaulins were placed over the silo to protect the fodder. Fig. 1(b) shows the attitude of the foundation ring after failure.

Prior to the failure, it had been noted that the drain tiles did not function; the silage juices seeped under the foundation ring and bubbled up to the surface near the foundation.

Fig. 2 shows the final position of the foundation ring. The failure occurred in the direction of the shallow excavation in the barnyard.

Soil Conditions

The silo was located approximately four miles north of the town of New Liskeard which is situated at the north end of Lake Timiskaming in northeastern Ontario. This area is located in the "little clay belt",[1] a clay plain formed after the retreat of glacial lake Barlow. The chief deposits of the little clay belt are normally consolidated and slightly overconsolidated varved clays. The surface elevation at the silo is 724 ft., about 140 ft. above the level of Lake Timiskaming. It is believed that the silo was situated near the top of the little clay belt deposits.

Two borings were made about 12 ft. from the foundation outside the failure zone. In one, vane tests were conducted from the 4 ft. level to a depth of 46 ft. The apparatus used was the "Geonor" vane, 110 mm. x 55 mm. as described by Andersen and Bjerrum.[2] In an adjacent hole, thin-walled tube piston samples were taken from depths of 3 to 30 ft. for laboratory tests. An additional vane boring was made in an undisturbed area approximately 100 ft. from the silo.

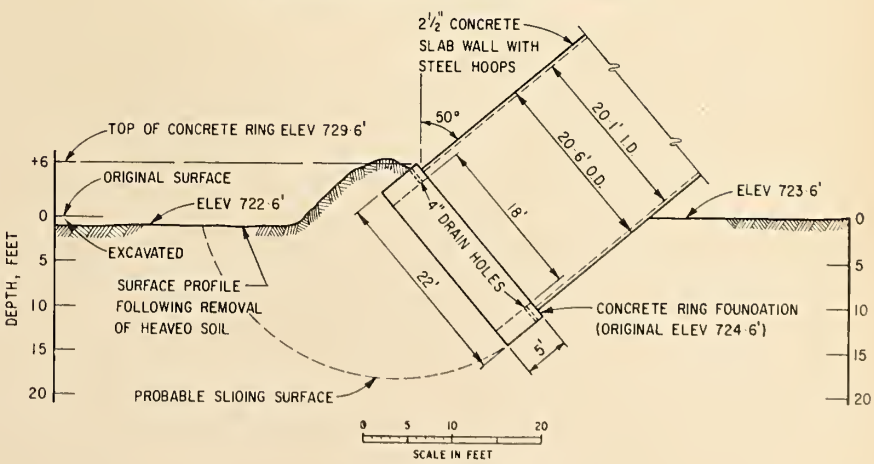
The results of the field and laboratory tests are presented in summary form in Fig. 3. The soil conditions consisted of normally consolidated varved clays to a depth of more than 46 ft., with a weathered crust from the surface to a depth of about 5 ft. Below 5 ft., to about 22 ft., the clay was very soft and sensitive. The soil strata consisted of very thin light layers between thicker dark layers. The dark layers averaged about ½ in. thick. Below 22 ft., the varves were much more distinct with layers of approximately equal thickness. Classification tests made on separated layers of the lower clay are presented in Fig. 3. The consolidation tests show the clay to be almost normally consolidated. The results of field vane tests are shown as solid lines in Fig. 3; the results of undrained laboratory tests are shown as points, each point representing a single test. The undrained triaxial tests were conducted at lateral pressures equal to the effective overburden stress. It can be seen that the laboratory strength tests are on the average lower than the field vane tests. The average of all the undrained laboratory strength results between 6 and 20 ft. gives a strength of 235 p.s.f. If the maximum value from each tube is averaged, a value of 295 p.s.f. is obtained. The average strength yielded by the field vane over the same ranges in depth in the two borings was 325 p.s.f.

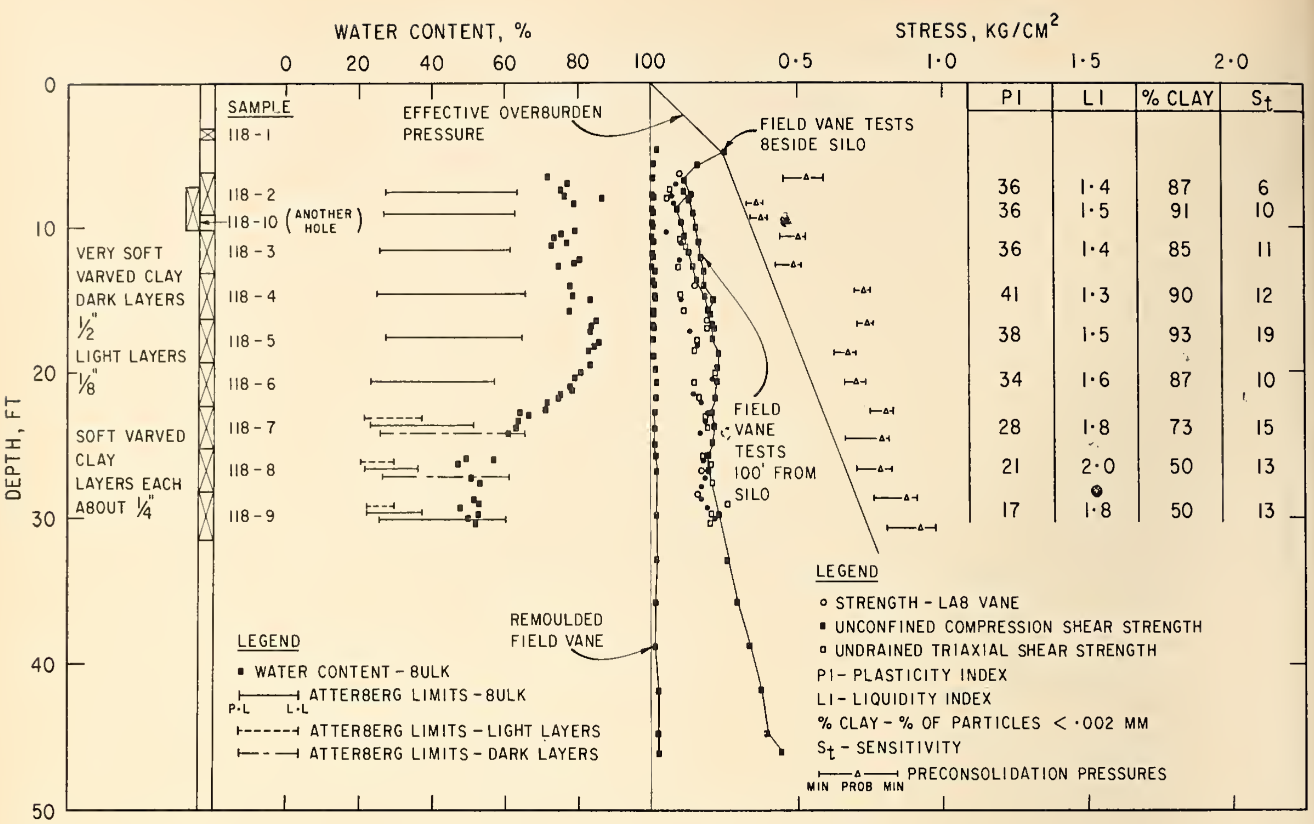
Analysis of the Failure

To conduct the analysis of the failure, three factors must be determined: the physical dimensions of the structure, the load, and the shear strength of the soil. Only the physical dimensions can be determined accurately. It is necessary to estimate the load, and there is also some question whether vane and laboratory strength determinations on varved clay are reliable.

The load is made up of the weight of the silo structure, the weight of the contents, the weight of the foundation ring and the weight of soil retained in the ring. Using the dimensions of the silo, the weight of the structure was calculated to be 50 tons—a figure subsequently confirmed by the silo manufacturer. The foundation ring weighed approximately 47 tons and the soil retained in the ring at 100 pcf was about 50 tons. The weight of the contents is less certain. The farmer estimated it to be 400 tons based on the yield per acre of forage crop. The manufacturer lists a capac-

Fig. 2 Details of the silo base after failure.





PI	LI	% CLAY	St
36	1·4	87	6
36	1·5	91	10
36	1·4	85	11
41	1·3	90	12
38	1·5	93	19
34	1·6	87	10
28	1·8	73	15
21	2·0	50	13
17	1·8	50	13

Fig. 3 Boring log and summary of test results.

ity of 450 tons of grass silage at 65% moisture content and 389 tons of corn silage at 69% moisture content. Gray[3] presents graphically the measured densities of corn silage and these measurements have been substantially confirmed in subsequent studies by Otis and Pomroy.[4] Using the density-depth relationships given by Gray[3] the weight of the silage was estimated to be 393 tons. Hence the total weight of the contents, structure, and soil retained in the foundation ring was estimated to be 550 ± 50 tons.

It has been the experience of the authors and has been confirmed by the test results, that field vane strengths are slightly higher than laboratory determinations. For bearing capacity computations the field vane strengths were used. Using Skempton's rule,[5] the shear strengths were averaged between the bottom of the foundation and a depth below the foundation equal to two thirds of its diameter, that is, 4 to 20 ft. Including the boring 100 ft. away, there were 26 strength measurements in this zone giving an arithmetic average strength of 325 p.s.f.

To apply the various bearing capacity formulae, it was decided to consider the foundation to be equivalent to a circular bearing area 4 ft. below the surface. The soil inside the foundation ring above 4 ft. was considered inert and contributed to the total load of 550 ± 50 tons.

Four methods of analysis were tried and are summarized in Table I. The factor of safety, F, listed is the ratio of the bearing capacity calculated from the shear strength to the estimated average bearing pressure. Table II lists the safety factors calculated using the average laboratory shear strength, and the average maximum laboratory shear strengths in one case.

The four methods of analysis were:

1) Skempton[5]
2) a modification to the above formula following the procedure of Skempton[6]
3) the formula suggested by Meyerhof[7]
4) the Fellenius circular arc method as described by Wilson.[8]

(1) Skempton's Method

For rapid loading on clay, Skempton[5] has proposed the following formula: $q_u = c.N_c + p$ where

- q_u is the ultimate bearing capacity,
- c is the average undrained strength of the clay,
- N_c is a factor depending on the shape of the foundation and its depth of embedment, and
- p is the overburden pressure at foundation level.

For this case, c was taken at 325 p.s.f. N_c for a 22 ft. diameter circular footing 4 ft. below the surface is 6.6. The overburden pressure, p, is equal to 400 p.s.fi q_u was calculated to be 2540 p.s.f. For the three load conditions assumed, 500, 550, and 600 tons, F, the safety factor, varied from 0.97 to 0.80.

(2) A Modification to Skempton's Method

Since the above formula does not take into account the adhesion between the soil above 4 ft. and the rough surface of the foundation ring, Skempton's formula was modified. In an earlier work, Skempton[6] recognized the adhesion and proposed that the bearing capacity be increased by a factor $(L/A).c'$, where L is the perimeter area of the footing in contact with the soil. A is the area of the base of the footing and c' is the adhesion between the footing and the foundation. Potyondy[9] has shown that the adhesion between soil and rough concrete is equal to the strength of the soil, in this case 500 p.s.f.

The modified formula becomes

$$q'_u = c.N_c + p + (L/A).c'$$

and gave a bearing capacity of 2900 p.s.f. and a range in F from 1.10 to 0.92.

(3) Meyerhof's Method

In the case of a buried circular foundation with a rough shaft bearing

TABLE I

Factor of Safety, for Four Methods of Analysis

Case	*Formula Used*	*F for Total Load Assumptions*		
		500 ton	*550 ton*	*600 ton*
1.	Skempton — $q_u = c \,.\, N_c + p$ (ref. 5) c = Average vane shear strength between 4 ft. and 20 ft. N_c = 6.6 p = 400 p.s.f. (Adhesion not considered)	0.97	0.88	0.80
2.	Modified Skempton (ref. 6) $q_u' = c \,.\, N_c + p + (L/A) \,.\, c'$ c and N_c as above L = perimeter area of footing A = area of footing c' = p.s.f. (Adhesion considered)	1.10	1.00	0.92
3.	Meyerhof (ref. 7) $q_r = c \,.\, N_{cqr} + K_s \gamma D$ N_{cqr} = 7.6 (rough concrete—full adhesion on sides) c = average vane shear strength between 4 ft. and 20 ft. K_s = 1 γ = 100 pcf D = 4 ft.	1.09	0.99	0.91
4.	Fellenius, as modified by Wilson (ref. 8) Circular arc through centre Adhesion included	0.94	0.88	0.78

on a purely cohesive soil, Meyerhof[7] proposes the formula:

$$q_r = c.N_{cqr} + K_s \gamma D$$

where

- q_r = ultimate bearing capacity.
- c = average shear strength = 325 p.s.f.
- N_{cqr} = a factor depending on shape of the foundation, the depth of the bearing surface and full adhesion between the soil and the shaft of the foundation = 7.6.
- K_s = coefficient of earth pressure between the soil and the shaft taken as 1.
- γ = density of the soil above the bearing surface = 100 pcf.
- D = depth of the foundation = 4 ft.

Hence,

q_r = 2870 p.s.f. and F varies between 1.09 and 0.91.

(4) The Fellenius Method

The Fellenius method is based on the premise that failure will take place on a circular arc. Thus, in the analysis, it is possible to take into account variations in the level at the surface of the clay. Wilson[8] has derived a method of locating the centre of the most critical surface for analysis by statics. Assumptions made were that only 3 ft. of soil were above the foundation level on one side, and that the soil above the foundation level had a shear strength of 500 p.s.f. The average shear strength below 4 ft. was taken as 325 p.s.f. To do the analysis, a slice one foot wide was taken through the centre of the silo. Because the failure surface has three dimensions, with a larger portion in the upper crust than in a two-dimensional slice through the centre, the Fellenius method can be expected to yield a safety factor somewhat low. Using this method, safety factors of 0.94, 0.88 and 0.78 were obtained.

Conclusions

The analysis of this failure has shown that there is reasonable agreement between the bearing capacity calculated from field vane strengths and the average bearing pressure applied by the structure. If the theoretical analysis is satisfactory the following implications may be stated as applying to soft normally consolidated varved clay with a range in properties similar to this site.

1. The field vane test will yield reliable undrained strength values for design purposes in medium to highly plastic varved clays. Since the maximum laboratory strength determinations are slightly lower than the vane strengths, the maximum, rather than average laboratory strengths, should be used in design.

2. Since Skempton's rule of using the average shear strength to a depth below the footing equal to two-thirds the width yielded reasonable agreement, the average vane strength, not the minimum, should be used for design.

3. It appears that the strength of the fissured crust and adhesion between the concrete and the soil deserve consideration in design. Hence, a bearing capacity formula such as Meyerhof's, which takes this into account, should be used for design.

This paper is a contribution from the Division of Building Research, National Research Council and is published with the approval of the Director of the Division.

Acknowledgements

"The authors wish to acknowledge the assistance of Mr. Arthur B. Campbell, Extension Specialist, Ontario Department of Agriculture, New Liskeard and Professor F. H. Theakston, Ontario Agricultural College, Guelph in this investigation."

TABLE II

Comparison of Test Methods as Applied to Meyerhof's Formula

Shear Strength p.s.f.	*Factor of Safety*		
	500-ton load	*550-ton load*	*600-ton load*
Average field vane strength = 325	1.09	0.99	0.91
Average laboratory strength = 235	0.83	0.75	0.69
Average of maximum strengths per sample = 295	1.00	0.91	0.84

References

1. **Soil survey of New Liskeard Englehart Area, Timiskaming District, Ontario.** Hoffman, D. W., R. E. Wicklund and N. E. Richards. Report No. 21 of the Ontario Soil Survey Experimental Farm Service, Dominion Dept. of Agriculture and The Ontario Agricultural College, 1952.
2. **Vane testing in Norway.** Andresen, A. and L. Bjerrum. Amer. Soc. for Testing and Materials, Special Technical Publication No. 193, p. 54-59, 1956.
3. **Farm service buildings.** Gray, H. E. McGraw-Hill, New York, 1955.
4. **Tower silo design.** Otis, C. K. and J. H. Pomroy. Agricultural Engineering, Vol. 42, No. 7, July 1961. p. 356-364.
5. **The bearing capacity of clays.** Skempton, A. W. Proceedings, Building Research Congress, London, 1951, p. 180-189.
6. **An investigation of the bearing capacity of a soft clay soil.** Skempton, A. W. Journal Inst. of Civil Engineers, Paper No. 5305, Vol. 18, 1942. p. 307-321.
7. **The ultimate bearing capacity of foundations.** Meyerhof, G. G. Géotechnique, Vol. 2, 1951. p. 301-322.
8. **The calculation of the bearing capacity of footings on clay.** Wilson, G. Journal Inst. of Civil Engineers, Paper 5282, Vol. 17, 1941. p. 87-96.
9. **Skin friction between various soils and construction materials.** Potyondy, J. G. Géotechnique, Vol. 11, No. 4, December 1961. p. 339-353.

ENGINEERING EDUCATION IN CANADA

To help mark the 75th Anniversary of the Engineering Institute of Canada, it was decided earlier this year to compile histories of the various engineering faculties in Canadian universities. Each university or institution teaching engineering was asked to prepare a brief history of its activities. The following, therefore, is a representative account of engineering education in Canada.

University of British Columbia

In 1905, Dr. H. M. Tory of McGill University came to Vancouver on a mission of higher education. In May, 1906, with characteristic vigor, he reported on the proposal to expand the work of McGill by forming the McGill College of Education, the forerunner of the University of British Columbia.

Dr. Harry Logan, University of British Columbia historian, tells of a personal appeal by Dr. Tory to Sir William McDonald, McGill's unfailing benefactor, to ask for donations of $5,000 per year for three years, the amounts necessary to maintain the College. The required legislation was passed, the funds were received in 1906, and thus McGill University College of British Columbia was born.

The College began with an enrolment of 48 students of whom 15 were in the first year of Applied Science. For the first year work, H. K. Dutcher was appointed Professor of Civil Engineering and David Blair was employed to teach Mechanical Drawing. Further appointments were made as the number of students increased. In 1914, Lawrence Killam was appointed Professor of Mechanical Engineering and E. G. Matheson as Lecturer in Civil Engineering.

The first session of the College was held in unused rooms of the King Edward High School. Afterward, several temporary quarters were found for the College until two frame buildings, on the site of the present Vancouver General Hospital, were built and occupied in 1912. The shop-work by Applied Science was done in a frame building east of the main buildings, now affectionately spoken of by UBC graduates as the "Fairview Shacks".

The McGill College applied science courses stopped at second year. Students proceeding toward professional degrees completed their training at McGill or other eastern universities. The addition of third and fourth year courses failed to materialize, partly because of a strong movement for a Provincial university, which continued unabated until, in 1908, "An Act to Establish and Incorporate a University for the Province of British Columbia" was passed by the McBride Government. The task of dealing with the insistent demands for a Provincial university was entrusted to Dr. H. E. Young, Provincial Secretary and Minister of Education.

The Point Grey site, present location of the University, was chosen in 1913 and Dr. F. F. Wesbrook, Dean of the Medical Faculty of the University of Minnesota, was appointed President. Clearing operations began at the site, and in 1914 work was begun on the Science Building. But the outbreak of the First World War put a stop to the ambitious plans for building and development at Point Grey. In 1922 the students, exasperated by the lack of government action, organized the "Great Trek". Finally, in 1925, classes moved to the Point Grey site.

Dr. Wesbrook's recommendations for new members of staff led to the appointment of several prominent educators, including Dr. R. W. Brock, Dean of Applied Science, who occupied this post with distinction until his untimely death in an airplane accident in 1935.

Dean J. N. Finlayson, who succeeded Dr. Brock in 1936, carried a heavy burden in dealing with the bulge in student enrolment, especially after World War II. Laboratories and classrooms were taxed far beyond their normal capacity until in 1950, when the peak enrolment had passed, the new Engineering building was ready for

The University of British Columbia Campus, 1961.

use to give some relief from makeshift accommodation. Dean Finlayson served as President of the Engineering Institute in 1948. Upon his retirement as Dean in 1950, he was awarded the honorary degree of Doctor of Science.

His successor was Dr. Hector J. MacLeod, Head of the Department of Electrical and Mechanical Engineering. Dr. MacLeod, a World War I veteran, rendered valuable World War II service with the National Research Council on problems of the Navy concerned with mines, torpedos, and degaussing of ships. For his war research, he was awarded the O.B.E.

In 1953, Dr. Henry C. Gunning, one of Dean Brock's outstanding students of the class of 1923, succeeded Dr. MacLeod. During 5½ years he forged strong links between the Engineering Faculty and many national and international organizations. He served as President of the B.C. Association of Professional Engineers, President of the Geological Institute of Canada, Chairman of the B.C. Section of the Canadian Institute of Mining and Metallurgy, and a number of other organizations. In 1959, Dr. Gunning left the University to accept a position as consulting geologist to the Anglo-American Corporation in Africa.

The present dean is Dr. David M. Myers, distinguished educator, formerly Head of the Electrical Engineering Department of the University of Sydney, Australia. Dean Myers, whose principal research interest is computer science, has received strong support by his colleagues in his efforts to promote a vigorous expansion of research in all engineering departments.

Growth trends at U.B.C. are indicated by student enrolment showing that in 1917-18 the total attendance was 416 students, of whom 38 were in Applied Science. Peak enrolment was reached in 1947-48, when veterans returning from World War II swelled the number of engineering students to 1,800, a figure exceeding, by a substantial margin, the present enrolment of 1,002 out of a grand total of 13,060 students in all faculties.

In recent years, research has become one of the major activities of engineering departments at U.B.C. In 1955, a research symposium, Dr. B. G. Ballard, Vice-President (Scientific) of the National Research Council, at N.R.C. headquarters in Ottawa, as Chairman, led to a closer liaison between the Council and the engineering departments at all Canadian universities. The interest and financial support from the Council, forthcoming as a result of that meeting, sparked a vigorous expansion of research and graduate work. Increased financial support from the Defence Research Board, and from industry, has increased the research budgets of all engineering departments. In Electrical Engineering and Metallurgical Engineering the research budgets now exceed the budgets for undergraduate instruction by substantial amounts. Student enrolment in the graduate school is approaching 100 students, nearly one-half of the number of students in the final undergraduate year.

Since the end of World War II the Faculty of Applied Science has witnessed a constant battle between its increasing enrolments and the buildings and facilities necessary to accommodate them. The engineering departments are now in the process of moving to a 20-acre site on another part of the campus. Chemical Engineering is now comfortably established in a new building and the other departments have reached various stages in their planning and design. The Faculty can look forward to the day, a few years hence, when it can occupy for the first time a set of buildings suitable and adequate to meet its needs.

Queen's University, Ellis Hall houses the Department of Civil Engineering and Library. The University observatory and the computing centre are located in this building.

Queen's University

Queen's University at Kingston finds its Faculty of Applied Science can trace roots to 1887—the same year the Engineering Institute of Canada was formed.

At that time a Kingston resident, John Carruthers, contributed $10,150 and pointed out a grassy field for the site of an $18,000 Science Hall. The limestone building, now home of the department of Mathematics, opened in 1891.

Two years later a locally-formed corporation leased the new building and set up the first School of Mining and Agriculture in Ontario. Science instruction at Queen's was strengthened a year later by the formation of the University's own Faculty of Practical Science with N. F. Dupuis as Dean.

Through the efforts of Dean Dupuis and Principal the Rev. G. M. Grant, the new faculty introduced courses in Chemistry and Mineralogy, Mechanical, Civil, Electrical and Mining Engineering and Biology.

The School of Mining under Dean W. L. Goodwin, and the new science faculty existed side by side, officially separate but integrated in practice, until 1897 when the Mining School became affiliated with Queen's.

By 1902 the B.Sc. degree was offered in eight courses and the old M.E. (mining engineer) degree had disappeared from the calendars.

The two were finally amalgamated by the Ontario Act of 1916 as the Faculty of Applied Science of Queen's University. It retains the same organization today with the addition of Physics, Engineering Drawing, Geological Sciences and Metallurgy as separate departments.

Today the faculty is spread among seven buildings, ranging from the 60-year-old Fleming and Ontario Halls to Ellis Hall, a million-dollar building occupied in 1959 by the Civil Engineering Department.

From a humble beginning in 1893 of five students and six staff members, applied science enrolment has risen to more than 800 this year. As well, more than 65 graduate students are currently doing research and study within the department.

In 1884 when practical science was introduced to the campus, engineering equipment consisted of a bench, an electric motor, and one or two lathes in the basement of an arts building.

Throughout the years funds were constantly made available for more and better equipment, greater library facilities and classroom expansion. Such have been the demands that a Bendix G15D medium size electrical digital computer installed in the Computing Centre in 1960, was recently replaced with the larger IMB 1620.

By situation and equipment the University is one of the best institutions for the study of Geological Sciences. Within a hundred miles many minerals are mined and nearby outcroppings of igneous, sedimentary and metamorphic rocks make a great natural laboratory. Annual field trips are made throughout the area by students and as many as 40 different mineral species have been found in one afternoon.

The variety of topographical features in the surrounding country affords the best of material for practice in all branches of surveying, including railway, topographic, hydrographic and land surveying.

The Canadian Locomotive Works, the largest locomotive shops in Ontario, are within a 10-minute walk of the University, and are open to students for study. Kingston has a large dry dock in whose yards steel construction can be studied practically. The locks of the Rideau Canal can be visited six miles from the heart of the city and there are several water powers within easy distance.

Each year a several hundred thousand dollar research program is carried out within the departments and a carefully developed graduate program is designed to give each post-graduate student individual attention. Master of Science degrees have been offered at Queen's since 1904.

An engineering student at Queen's is given a thorough and integrated training in the fundamental matter in the fields covered by his curriculum. Dean H. G. Conn, believes a Queen's engineering student develops an ability to learn for himself so he can keep abreast of changing conditions and current problems.

Fig. 1—Ecole Polytechnique from 1874 to 1905

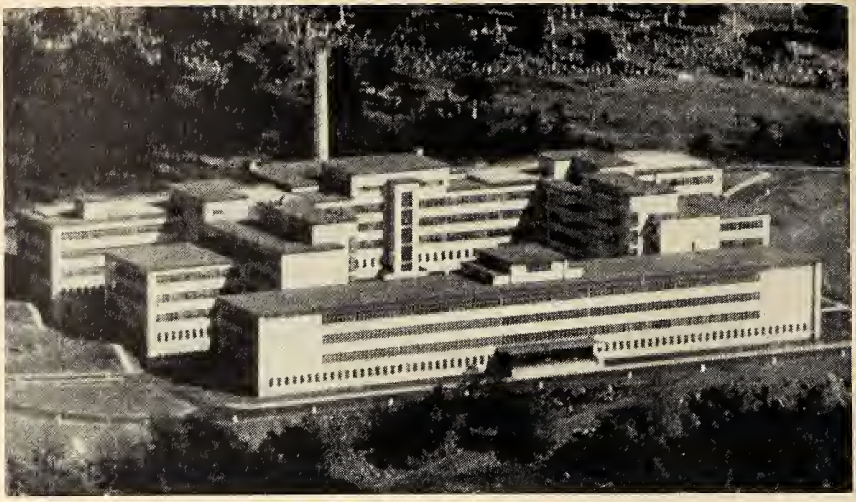


Fig. 3—Ecole Polytechnique since 1958

École Polytechnique

One of the oldest engineering schools of Canada, Ecole Polytechnique of Montreal, was founded in 1873, by Messrs Urgel-Eugène Archambault, Charles-A. Pfister and the Honourable Gédéon Ouimet. The first lectures were given within the building of Ecole du Plateau, but it soon occupied a small brick building of its own, just besides. This first site was between Ontario and St. Catherine Streets, near Jeanne Mance, where the future Place des Arts will stand.

At the start, the course covered four years of studies and the first graduating class of 1877 consisted of five students, among whom was Louis-Stanislas Pariseau, who lived to the age of 101 years, and who, in 1956, at the age of 99, and still walking alertly, attended the ceremony of the laying of the corner stone of the new $15 million building of Polytechnique, on Mount Royal.

In 1887, Ecole Polytechnique became affiliated to Laval University, which had a branch in Montreal; seven years after, however, the engineering school, although keeping its affiliation to the University, was incorporated as a financially independent body, which status still applies. Since 1920, it has been affiliated to the University of Montreal.

It soon became apparent that the school had to move into larger quarters, and the construction of a new building was started in 1902 on St. Denis Street, near St. Catherine. From 1905, it was there that Ecole Polytechnique progressed steadily during more than half a century. No sooner had this building of St. Denis Street been inaugurated than the need was felt to build an annex in order to house some laboratories and also a section of Architecture, which operated under the jurisdiction of Ecole Polytechnique from 1907 to 1923, at which time it was transferred to the new Ecole des Beaux-Arts. As time went by, other buildings were erected around the main structure: in 1932, a wing was built parallel to St. Catherine Street to contain a gymnasium as well as hydraulic and materials testing laboratories; in 1941, a new library and a large auditorium are added; finally, in 1945, along Sanguinet Street, and completing a square shape, a long wing was built to house various laboratories of the Electrical, Mechanical, Chemical and Geological Engineering departments, as well as drafting rooms.

The course of studies which had a duration of four years at the beginning, was increased to five years in 1922. At first, the curriculum was common for every student and was more or less oriented toward civil engineering, the fields of public works and construction being then the most promising from a placement viewpoint. Around 1910, Ecole Polytechnique offered specialization in five different branches in the junior and senior years, but most students chose civil engineering. In 1922, a General Engineering course of five years was the only one offered; it had a certain slant toward civil engineering, but was nevertheless quite wide in its coverage. Students wishing to get a specialized degree had to study for a sixth year.

From 1943 to 1959, following the industrial development brought about by World War II, and also because of the difficulty of adding new subjects to an already heavy curriculum, Ecole Polytechnique offered a system of semi-specialization in the last two years of studies; these options, which were generally combinations of two associated fields, were slightly modified at the beginning, but were finalized as follows: Public Works and Buildings, Mechanical & Electrical Engineering, Mining & Geological Engineering, Chemical & Metallurgical Engineering.

In 1955, construction of the present building of Ecole Polytechnique was started on the campus of the University of Montreal, on the slopes of Mount Royal. This was brought about by the rapid increase in the registration of students at the School on St. Denis Street, with limited possibilities for expansion. The new building has a volume of more than eight million cubic feet and a floor area of some 500,000 square feet. The first lectures were given there in September, 1958. Although it has its own Board of Governors and a separate administration, Ecole Polytechnique is, in fact, the Faculty of Engineering of the University of Montreal.

In January, 1958, a new curriculum was adopted offering full specialization in the following eight fields: Civil, Mechanical, Electrical, Chemical, Metallurgical, Mining, Geological Engineering, and Engineering Physics. This new curriculum involves a common course of studies for two and a half years, the remainder of the five years being specialization. Accent is given on fundamentals, and an effort has been made to maintain as general an education as is possible within the bounds of a specialized course. In 1962, some 270 students received their engineering degree from Ecole Polytechnique, or, more precisely, from the University of Montreal.

University of Western Ontario

The founding of the Faculty of Engineering Science in September of 1960 fulfilled the dream of the founders of the University of Western Ontario, who in November, 1877, agreed to organize a non-denominational School of Arts, Law, Medicine and Engineering to meet the educational wants of fast-developing Canada West. Initially major emphasis was devoted to the building and development of the Faculties of Medicine, Arts and Science, but some thought was given to engineering as early as 1925, when special arrangements were made for selected Western students in science to enter with advanced standing Queen's University Faculty of Applied Science. It was not until after World War II that increased emphasis on technology made it advisable to consider "rounding out" the original plan for Western as envisaged by the founders, and in July, 1954, following months of planning the Department of Engineering Science was formed. Originally, a two-year program was to be offered which would qualify candidates for admission to third year of engineering courses established at other universities. Shortly after this, in May, 1956, a four-year program leading to the degree of Bachelor of Engineering Science was authorized by the Board of Governors and approved by the Senate.

Also in May of 1956 there was formed the Advisory Committee on Engineering Science which group of prominent engineers from Canadian industry, business and government agencies has played a vital role in the rapid and sound growth of Western's newest faculty.

From the beginning in 1954, the new department grew under the capable guidance of Professor L. S. Lauchland, its original member and head. Enrolment grew steadily from 20 in the first class to almost 200 five years later. The magnificent new Alexander C. Spencer Faculty of Engineering Building occupied in June, 1959, provides the faculty with the most modern classroom and laboratory facilities, on a scale sufficient to provide for the projected maximum undergraduate enrolment. Already additional facilities are being planned to provide for expanding research and postgraduate training.

The Faculty of Engineering Science at Western is devoted to the teaching of the fundamentals of engineering. The curriculum is designed to develop a thorough understanding of the engineering sciences and of the mathematics and basic sciences on which these are founded. Emphasis is therefore placed on developing an understanding of principles rather than a superficial facility in their application. The first two years of the four-year course are completely unified, the object being to develop a broad base of understanding. About three-quarters of the third year is devoted to an extension of this unified core of basic and engineering science subjects. During the third and fourth year the student selects a group of elective subjects enabling him to gain a deeper insight into certain of the engineering sciences which he feels will best prepare him for professional practice. At present these options are oriented toward the chemical, civil, electrical and mechanical branches of the profession, although an effort is made to de-emphasize the use of this nomenclature.

Laboratory exercises are conducted in small groups so as to best develop the resourcefulness, creativity and judgement so necessary to engineering design. A major course in the final year of the program is a project and thesis. Here each student is given personal guidance and encouragement to produce original work and the quality of many of the projects is remarkably high. Future laboratory and shop facilities will be sufficient to provide this type of training for the maximum enrolment forecast for the fourth year. The curriculum includes a continuing study of selected humanities and social sciences to encourage the development of attitudes and background appropriate to effective citizenship and professional practice.

Until 1960 the effort of the Faculty was directed almost totally to the development of the undergraduate curriculum together with the planning and construction of the necessary building, classroom and laboratory facilities. This much now is accomplished and a vigorous research program involving several staff members is already well underway. In addition a program of post graduate study has been planned and the fall of 1962 will see the enrolment of the first graduate students in engineering science.

Future plans call for the eventual enrolment of about 400 undergraduate and 50 graduate students which level should be attained in three to five years.

Loyola College

Loyola's Department of Engineering was established in 1943 to give instruction in the first three years of the five year course leading to a Bachelor of Engineering degree. Currently students at Loyola have the option of following courses of study in Chemical Engineering, Civil Engineering, Electrical Engineering, Engineering Physics, Mechanical Engineering and Mining or Geophysical Engineering. In any of these branches the student may elect to proceed to a Bachelor of Science degree with an engineering certificate in four years, or to an engineering certificate in three years.

The average enrolment during the past five years has been 192, but the present facilities dictate an optimum enrolment of 210. For several years the engineering students comprised about half the students enrolled in the Science faculty. An active student-run section of the Engineering Institute of Canada provides an extra-curricular program of field trips, technical films and technical talks by graduate engineers.

Facilities for engineering at the College are located in two of Loyola's seven buildings located on a 50-acre site in the west end of Montreal. These include two draughting rooms and laboratory facilities for strength of materials, physical metallurgy, circuit analysis and mechanical engineering. A surveying field school is conducted on and near the campus during the spring. Studies in the basic sciences are undertaken in the new Drummond Science Building while lectures in mathematics are given in the College's main and central buildings. Study areas are provided in the main College library and the newly constructed science library. The College also plans a 150,000 volume library to be completed in 1963.

The present student residence accommodates a limited number, but facilities for more than 300 students will be available on completion of a new student residence under construction at the present time.

The Engineering Faculty at the College consists of seven members with a well balanced background of teaching, research and industrial experience. Several research projects are being carried out under Government sponsorship, at the faculty level.

Planning for near-term developments is mainly concentrated on improvement of existing facilities but for longer-term the construction of an Engineering building is scheduled to commence in 1964 and with it expansion of the present courses in Civil, Electrical and Mechanical Engineering to five year courses.

University of Western Ontario, Alexander Charles Spencer Faculty of Engineering Building.

McGill University

McGill University was founded by bequest of the Hon. James McGill in 1811. It received a Royal Charter making it a university in 1821, and there was a reorganization with an amended charter in 1852. Under the amended charter, Sir William Dawson became the first Principal of the University, taking office in 1855, and in that year he inaugurated a series of "Popular Lectures in Applied Science" within the Faculty of Arts. These lectures were expanded and consolidated in 1856 into a curriculum of two years duration leading to a diploma in Civil Engineering. The first graduate from this curriculum, one Oliver Gooding, received his diploma in 1858, and is thus the first McGill graduate in Engineering, and also Canada's first graduate in Civil Engineering.

In the next seven years 15 more diplomas were granted, but it seems that some difficulties developed during the Session 1863-64 as there were no further Engineering graduates through the next seven years. One further graduate received a diploma in Civil Engineering in 1871. In the Session of 1871-72 the instructional staff was grouped into a separate Department of Applied Science in the Faculty of Arts, and on Monday, February 19, 1872, the inaugural lecture of this department was delivered in the William Molson Hall of the University by Professor George F. Armstrong, the recently appointed Professor of Civil Engineering and Applied Mechanics. In the foreword of his address, Professor Armstrong stated:

> *"The School of Practical Science which this lecture inaugurates is the first attempt which has been made in British North America to establish the systematic teaching of Applied Science".*

There is insufficient space here to print Professor Armstrong's lecture in full, but it is, in fact, a profoundly interesting document as he states many views on engineering education which, if removed from the context and printed separately, might well be regarded as something which had been written within the last two or three years.

With the establishment of a Department, the length of the course was increased to three years, and graduates were awarded the degree of Bachelor of Applied Science. The first class graduating from this course, six in number, received their degrees in 1873 and one of its members, Clement H. McLeod, subsequently joined the teaching staff of the Department and served the University with distinction until his death in 1917.

The first staff of the Department comprised eight professors and one lecturer, and there were three divisions of study, namely 1) Civil and Mechanical Engineering, 2) Assaying and Mining, and 3) Practical Chemistry. In the Session 1878-79, all teaching and administrative responsibilities in Engineering were transferred from the Faculty of Arts to the Faculty of Applied Science which was set up in that year. Professor Henry T. Bovey who had replaced Professor Armstrong in the Session 1876-77 as Professor of Civil Engineering and Applied Mechanics, was appointed first Dean of the Faculty. The length of the undergraduate class was increased to four years, and the Civil and Mechanical courses were separated. The first name Chairs in the Faculty of Applied Science appeared in the University Calendar in the Session 1889-90. Henry T. Bovey is a William Scott Professor of Civil Engineering and Applied Mechanics, and Charles A. Carus-Wilson is the Thomas Workman Professor of Mechanical Engineering. In the Session 1891-92, the Division of Electrical Engineering appears for the first time, and Surveying is added to the Civil Division. In 1896-97 the Division of Architecture first appears with S. H. Capper as the first Professor of Architecture. Two years later, the name of the Engineering degree was changed to Bachelor of Science (B.Sc.) and the Bachelor of Architecture (B.Arch.) was instituted.

The early years of the new century showed considerable developments. In 1905 the Division of Transportation was added, and in 1907 this Division was changed to the Department of Railways. In 1908 Chemical Engineering and Metallurgical Engineering were introduced and in this same year, Dean Bovey moved to a post at Imperial College, London, being succeeded by Dr. Frank D. Adams, who served the Faculty from 1908 until 1924 and who was a Fellow of the Royal Society of England. In 1920 the old Division of Practical Chemistry and Metallurgy were discontinued, but there were no further significant changes.

Dean Adams retired in 1924 and was succeeded by Henry Martyn MacKay, who served until his death in 1930. It was during his period of office that the name of the Engineering degree was changed from Bachelor of Science to Bachelor of Engineering, and the name of the Faculty was changed from the Faculty of Applied Science to the Faculty of Engineering.

Starting in the Session 1927-28 the Faculty required either Senior Matriculation or the completion of the First Year B.Sc. course in the Faculty of Arts and Science, for admission to the four-year course in the Faculty of Engineering. Most Canadian engineering faculties introduced similar requirements about this time, so that Canadian schools of engineering have since that time been on a five-year basis following four years of High School. This contrasts with the common American practice of awarding a Bachelor of Engineering degree on four years of university following four years of High School.

The beloved Ernest Brown succeeded MacKay as Dean in 1930, and served through the next 12 years. This, as in most universities, was a sad period during which financial limitations seriously retarded development and it was barely possible to hold one's own.

On his retirement in 1942 Dean Brown was succeeded by Dr. J. J. O'Neill, past president of the Royal Society of Canada and formerly Dean of the Faculty of Graduate Studies and Research, and before that Dean of Science. It was he who guided the Faculty through the difficult days of the war, and the even more difficult but much more exciting days following the end of the war, when the Faculty expanded enormously to cope with the onrushing veterans. It was during this period, in 1949, that McGill began registering entering Engineering students directly in the Faculty of Engineering and administration of the first year became its responsibility. The Faculty reached a total enrollment of some 1800 during these hectic days, and then experienced a reduction in numbers as the wave of veterans tapered off, although there was a subsidiary smaller wave towards the end of Dean O'Neill's tenure as a smaller return of veterans from the Korean war again swelled our ranks.

Professor R. E. Jamieson succeeded Dean O'Neill in 1952, and in his five years of office laid sound plans for the future development of the Faculty. For the first time in more than 20 years it was possible to make plans with a reasonable hope that they would not be rejected because of lack of money or have to be postponed because of more pressing needs to cope with unprecedented numbers of students. Some of the fruits of Dean Jamieson's planning can be seen in the new building at the corner of Milton and University Streets, which is connected with the existing buildings. It provides completely new quarters for the Department of Electrical Engineering, the School of Architecture, and for those parts of the Department of Mathematics which work closely with the engineers. It provides general auditoria and lecture room space and drafting rooms for all engineering students, and also houses McGill's computing centre. During this period also, research work and post-graduate studies started to become a more significant part of the Faculty's work.

In the last five years, under Dean D. L. Mordell, further progress has been made in the evolution of the curriculum to meet tomorrow's needs, and in the development of graduate work and research. The interests of the Faculty have spread widely, and in particular, through the operation of the Brace Research Institute, are reaching to many foreign countries and are serving them from an experimental station located some 2500 miles from the campus on the Island of Barbados. 2500 miles in the other direction, a team of McGill engineers are engaged on problems of arctic engineering in Canada's northern outposts.

Ontario Agricultural College

In 1874, the School of Agriculture was established at Guelph and in 1880 became the Ontario Agricultural College affiliated for academic purposes with the University of Toronto. During this early period, engineering instruction consisted mainly of practical farm mechanics and surveying, given to agricultural students. In 1928, the Department of Physics united with the Farm Mechanics Department to form a Department of Agricultural Engineering.

One of the early engineering services made available to farmers was the field surveying and the preparation of plans for tile drainage systems. Under the direction of Professor F. L. Ferguson from 1919 to 1956, this engineering service grew steadily to become a prominent activity that contributed greatly to the recognition and development of agricultural engineering in Ontario.

Since 1946, under the leadership of Professor C. G. E. Downing, the Department of Agricultural Engineering, now the Engineering Science Department, has undergone a rapid expansion to meet the needs of Agricultural Mechanization in Ontario.

In 1955, a joint program was arranged with the Faculty of Applied Science and Engineering of the University of Toronto, whereby, students, on completing the four-year course for the B.S.A. degree in the Mechanical Division of the Agricultural Engineering option can proceed to the fourth year of the Mechanical Engineering course at the University of Toronto, leading to a degree B.A.Sc.; in 1947 this arrangement was extended to include Civil Engineering.

The Department has grown from a staff of four in 1946 to 20 today. Approximately 20 students are graduated each year. At present there are also 12 graduate students and four special students enrolled in the Department.

The Department also offers courses in Agricultural Mechanics in the two-year Associate Diploma course, the object of which is to train students returning to farming.

Most laboratory equipment and research apparatus is now housed in an adjacent building known as the Engineering Annex, for lack of space in the present Engineering building.

Engineering research is a major area of activity in the Department. Active research studies are in the fields of hydrology, drainage, field machinery, traction, farm structures, snow accumulation, ventilation, and materials handling.

University of Saskatchewan

The University of Saskatchewan opened its doors in 1909 and in 1912 four students entered the School of Civil Engineering. The following year C. J. Mackenzie was appointed lecturer, and with A. R. Greig and J. P. Oliver constituted the engineering members of the faculty of the School. In 1914 there were 14 students registered, but in 1916 the School closed until 1919, the staff and students being all involved in World War I. On its re-opening in 1919 the enrollment totalled 16 students. By 1921 the growth was such that the following seven additional members of staff were appointed: F. L. Code, I. M. Fraser, C. H. Jackson, R. A. Spencer, G. M. Williams and W. G. Worcester, and in 1923 W. E. Lovell, making it possible to give as well as the Civil Engineering course the third year of Mechanical and Electrical Engineering. The enrollment in 1921-22 was 44 undergraduates. In 1922 C. J. Mackenzie was appointed Dean of the College of Engineering.

As time went on additional space for laboratories and lecture rooms became necessary. To the Agricultural Engineering laboratory, built in 1910 to 1912, substantial additions were made from 1919 to 1921 and in 1920 it became known as the Engineering Building. In 1923 the Ceramic Engineering laboratories were built and the full course initiated in this subject under Professor W. G. Worcester. Two years later, in March 1925, the building was destroyed by fire. By January 1, 1926, it had been replaced by a fireproof brick structure, the main nucleus of the present Engineering Building. To this the further growth of the College has necessitated substantial additions including the west wing and the new Agricultural Engineering laboratories and considerable alterations and renovation to the main building.

The Agricultural Engineering course, started in the College of Agriculture in 1912, became, in 1926, under the leadership of A. R. Greig and Evan A. Hardy, one of the departments of the Engineering College, but was under dual sponsorship until 1947, when it was placed completely under Engineering.

By 1931 the undergraduate body numbered more than 250. In 1931 a complete course in Chemical Engineering was organized, and in 1935 this was joined by courses in Engineering Physics and Geological Engineering. All three courses require a student to be of honours scholastic standing to enter his second or third year.

In spite of the Depression and the drought suffered by the West in the 1930's which resulted in salary cuts and an almost complete absence of summer work for students, the work of the University and the College increased with no loss of initiative or standards. During this period a student could attend the University without paying fees for one year, but had to clear this debt before he received a degree. This statesman-like policy on the part of the University gave many young people in these desperate times the opportunity to acquire knowledge. From this group have come some of the most distinguished graduates of the University.

Just after emerging from this above period of trial World War II erupted and the University contributed in every way possible towards the war effort. The clock was set two hours ahead of Mountain Standard time and classrooms were busy from 8:30 a.m. to 11:30 p.m. The machine and blacksmith shops were, for a while, occupied throughout the day and night by Army personnel taking courses. It was not uncommon for staff members to spend three to four nights a week on courses for personnel of the Armed Services in addition to their regular teaching duties.

In 1940, Dean C. J. Mackenzie was appointed President of the National Research Council and his position as head of the College was taken over by R. A. Spencer.

During World War II the enrolment in the College dropped to 440 but in the immediate post-war period it rose to 1,150. This period, when the College dealt with the great wave of returned men, was a continuance of strenuous times but it had much that was interesting and rewarding.

In 1947 the final year of an Electrical Engineering course was initiated, in 1955 Petroleum Engineering and in 1962 Mining Engineering. In 1949 the Ceramic Engineering course, ably given by Professor W. G. Worcester from 1922-1947, was discontinued.

In 1954, Dean R. A. Spencer retired and was followed by I. M. Fraser, and in turn in 1958 by Arthur Porter who resigned to accept an appointment at the University of Toronto in 1961. The present Dean is J. B. Mawdsley.

During Dr. Porter's tenure graduate work towards the M.Sc. and Ph.D. in Engineering was greatly stimulated; this year there are more than 50 in these courses. Also at this time the undergraduate courses in Bachelors of Science in Engineering Science in most engineering departments were initiated for men of honours standing and ability. This small percentage of the undergraduates receive a greater amount of fundamental training which will better fit them for graduate work and research.

After the post-war surge subsided, the number in the College dropped to 405, in 1951-52, then steadily rose to 1,100 in 1957-58 and has remained close to this figure since.

Saskatchewan Engineering Building.

Dalhousie University

Previous to 1902, Dalhousie University offered no fully developed engineering courses. The need for higher technical education had, however, been recognized and a beginning was made more than 10 years earlier. In 1891, through the efforts of Dr. J. Gordon MacGregor, Professor of Physics, and the cordial and disinterested co-operation of the leading engineers of the City of Halifax, a Faculty of Science was organized, in which, in addition to the regular courses in pure Science, short technical courses were offered in such branches at Surveying, Hydraulics, Municipal Engineering, Mining and Metallurgy. These courses were conducted by experienced engineers and were found to be of much service to students looking forward to engineering work. They did not profess to be exhaustive technical courses, and the students who passed them were not granted degrees in engineering. Students who wished to proceed were obliged to go (usually for about two years) to McGill, Cornell and similar institutions. Records indicate that the numbers participating were comparatively small, but the courses offered helped to satisfy a definite want.

In 1902, the School of Mines was opened with an enrollment of 10 students. Well-equipped geological mining and metallurgical laboratories were established. Two years later, in 1904, a Department of Civil Engineering was added with an enrollment of 21. It was then no longer necessary for a student to go elsewhere for a degree course in Civil or Mining Engineering. Those proceeding to a degree in Mechanical or Electrical Engineering studied two full years at Dalhousie, completing two additional years at some other institution. By 1908 the enrollment in the Engineering Faculty had increased to about 70 students.

In 1906, discussions were started with the Government of Nova Scotia, and other Maritime universities, with a view to further expansion of the engineering course. As a result, there was passed by the Legislature the "Technical Education Act of 1907" which provided for the founding of the Nova Scotia Technical College a government supported institution, which opened for classes in September, 1909, under the Principal, Dr. F. H. Sexton, who had been a member of the Dalhousie Faculty of Engineering. With this date, Dalhousie's relations to technical education entered upon a new phase. The third and fourth year courses in Civil and Mining Engineering were discontinued, and the Faculty of Engineering as such, ceased to exist. Among the members of the last graduating class were such well-known engineers as C. J. MacKenzie, former President of the National Research Council of Canada and Geoffrey Geraghty and Dennis Stairs of Montreal.

From that date, students completed a two-year course common to all branches of engineering, at Dalhousie or some other associated university, and many then proceeded to the Nova Scotia Technical College for their final two years to the Bachelor of Engineering degree in Civil, Electrical, Mechanical or Mining Engineering. Later, as additions to the course demanded it, the period at the universities was increased to three years, making the total degree course five years from junior matriculation. The Nova Scotia Technical College has more recently added degree courses in Chemical and Metallurgical Engineering.

The first Professor of Engineering and Head of Department was C. D. Howe, who was Chancellor of Dalhousie from 1957 until his death in 1960. He was succeeded in 1913 by Professor J. N. Finlayson, later Dean of Engineering at Manitoba and more recently at the University of British Columbia; in 1919 by Professor R. A. Spencer, and he, in 1920, by Professor W. P. Copp who served continuously until his death in 1946. H. R. Theakston, who had been appointed to the Engineering Staff in 1921 became Head of Department, and subsequently Rt. Hon. C. D. Howe, Professor of Engineering, a chair which he continues to occupy. The staff has been increased over the years to four full-time members, as well as a number of student instructors in various subjects.

The Department has changed its location three times since its inception in 1909. Housed first in the Forrest Building until 1915, it then moved to new quarters in the Science Building at Studley, shared with Physics and Chemistry. In 1945, when two Navy buildings erected on the Campus during the war were turned over to the University, the Engineering Department took over about two-thirds of one of these after extensive interior alterations had been made, and which it shared with the Geology Department. These quarters were occupied for 15 years until the most recent move to its excellent and commodious quarters in the new Sir James Dunn Science Building in May, 1960, which it shares with Physics and Geology.

The registration of students in the Department has steadily increased during the years. From an average total for the Department prior to World War I of approximately 40 students, it has risen for the 1961-62 year to 219 students; an all time high, excepting the three years immediately following World War II when the influx of ex-Service students swelled the registration to abnormal figures.

In co-operation with the Department of Physics, the Department also participates in the preparation of students for the degree of Bachelor of Science in Engineering Physics.

Assumption University of Windsor

No one seems to know exactly when pre-Engineering was first taught at Assumption College. The University of Western Ontario did not offer pre-Engineering, and did not recognize the two years of pre-Engineering beyond Grade XII at Assumption. There is, therefore, no record of such a course in Western's official announcements and files. It seems that the late 1920's marked the humble beginnings, and in the alumni roster there are alumni listed who had the first college education in pre-Engineering at Assumption College in the early 1930's.

In addition to the subjects which were part of the General Arts and Science curriculum, Mechanical Drawing, Descriptive Geometry and Surveying were offered. For a long time these special courses were given by professional graduates from industry. These part-time instructors could only come to the campus in the evening or on Saturday mornings, and the students were left to do most of the work at home.

These courses continued until the appointment of F. A. DeMarco to the staff in September, 1946, when the entire pre-Engineering program was transferred to the regular day-time sessions and integrated with the other programs.

Since the University of Western Ontario did not recognize the program, the curriculum was primarily designed to fit into the five-year co-op program at the University of Detroit, and indeed nearly all of the students went to Detroit for their degrees. Assumption students always did well there, and out-performed the students from other pre-Engineering schools.

Assumption received its University Charter in 1953. Following friendly negotiations — its program was accepted by the Senate of the University of Toronto. Queen's University, while approving the program for admission to the second year of a four-year program, preferred to leave the admission of students on an individual basis. In the ensuing years an increasing number of students transferred to Toronto and Queen's, but the bulk of our certificate holders still found the University of Detroit the least costly and most convenient.

With the affiliation of the non-sectarian Essex College in 1956, the responsibility for pre-Engineering was given to that institution. One of the first studies asked of Dr. DeMarco, then acting Principal of Essex College, was the investigation of the possibility of expanding the Engineering program to the degree level. The Board of Directors of Essex College created an Engineering Education Committee to work with Dr. DeMarco.

In May, 1957, the Committee recommended to the Board of Directors "that Essex College make the necessary arrangements to offer the full program in Chemical, Civil, Electrical and Mechanical Engineering, adding the second year beyond Grade XIII in 1958, the third year in 1959 and the fourth year in 1960, subject to the conditions that adequate housing facilities and teaching faculty be provided, and that plans for the construction of a fully-equipped engineering building within five years be initiated". This recommendation was accepted by the Board of Essex College in the summer of 1957.

In the fall of 1959, within a new academic organization structure at the University, the Faculty of Applied Science was created, and for a few weeks the Faculty was administered by means of a Committee of departmental heads, with Dr. M. Adelman as Chairman. The Committee proved to be unwieldy in the everyday operations of the Faculty, and in October Principal DeMarco was appointed Dean of the Faculty by the Board of Directors of Essex College and the Board of Governors of the University.

In 1959, a graduate program was started in the Extension Division. This program met with ready favor among the engineers in the area who wished to up-date their previous training or who sought opportunity for an advanced degree. It also served the purpose of providing higher level courses which maintained the post-graduate and research interest of the highly-qualified faculty. These extension courses were eventually integrated into a full-time Master's program following the graduation of the first crop of undergraduates in 1961. It was gratifying to the faculty to see the leading students in each department all return for graduate work.

Nova Scotia Technical College, Administrative Building with Library on Top Floor.

Nova Scotia Technical College

Nova Scotia Technical College was established in Halifax by an act of the Provincial Legislature and in agreement with the existing universities of the area. Under the agreement, now involving eight institutions of higher learning in three provinces, the Associated Universities give the first three years of the engineering degree course, as a common course, and present successful students with a diploma. This diploma constitutes the entrance requirements for the College where the student, after an additional two years, receives his Bachelor of Engineering Degree in his chosen branch.

The Department of Militia and Defence granted the "Old Drill Shed Property" on Spring Garden Road as a site for the College and the first building was completed on September 24, 1909, just four days before classes began in Civil, Electrical, Mechanical and Mining Engineering. Dr. F. H. Sexton was the first President of the College and he remained at the helm until 1947. Under his guidance additional buildings were constructed as required, the College registration fluctuating between a low of seven in 1917 and a high of 74 in 1933. During the depression of the 1930's, registration reached a prewar high as men flocked to the halls of learning to improve their knowledge and enhance opportunities for employment. In both 1933 and 1935 the graduating class totaled 37. In the latter year the degree was changed, to conform to changes in the curriculum, from B.Sc. to B.E.

In the years following World War II registration climbed to a maximum in 1949-50 of 430 undergraduates of whom 175 received degrees in May, 1950. In addition to these undergraduates the College housed, on Campus, students with their families in "temporary" quarters and numerous informal dances, kindergarten classes and an active student wives club resulted. More recently the graduating class has averaged 110-120 per year with, in addition, several graduate students receiving the M.E. degree. Starting in the fall of 1962 the College will accept candidates for registration towards a Ph.D.

1947 was a momentus year in the history of the College. Dr. Sexton retired after 40 years as administrative head of the only engineering degree granting institution in Nova Scotia. He was succeeded by Dr. A. E. Cameron under whom the College Act was completely revised to establish a Board of Governors including representation by the Presidents of the Associated Universities, a Senate including representation by the Professors of Engineering of the Associated Universities and a teaching faculty responsible under the Senate and the Board for instruction in Chemical, Civil, Electrical, Mechanical, Metallurgical and Mining Engineering at both undergraduate and graduate level. The academic relationship with regard to the Associated Universities and their three year diploma course was continued.

The period 1947-57 saw expansion of the campus physically as adjoining property was acquired, and an almost doubling of class rooms and laboratory space with the addition of a wing to the Chemical and Mining Building, and the construction of a new building, the Macdonald Engineering Building to house Civil Engineering and some sections of other departments.

In 1957 Dr. Cameron retired and was succeeded by President Jack Hoogstraten who resigned in 1960 to become a Vice-President of the University of Manitoba. Dr. G. H. Burchill, Professor of Electrical Engineering and a member of the staff of that department since 1928, was appointed Acting President until the arrival in the spring of 1961 of Dr. G. W. Holbrook.

During 1961 a major construction project was completed. This included a three-wing type building attached at the south end of the Macdonald Engineering Building, the new construction housing administration and faculty offices, the library, a series of lecture and drafting rooms and new laboratories for both Electrical and Mechanical Engineering. Also in 1961 a School of Architecture was established at the College. Entrance requirements to the School are completion of the first two years of the engineering course at the Associated Universities, the student then remaining on the College Campus for an additional four years.

Since 1946 the College has paid honour to outstanding engineers in the fields of industry, government and education by conferring on them the degree of Doctor if Engineering Honoris Causa. Several of those so honoured are older graduates of the College who have gained prominence in their chosen field, some close to home, others in distant areas. Among those may be mentioned J. B. Hayes Civil '16) and I. P. McNab (Mec '13) both past presidents of the Engineering Institute of Canada, F. M. Dawson (Civil '10), A. E. MacDonald (Civil '20), H. R. Theakston (Min '21) and G. H. Burchill (Elect '23) who collectively have been directly responsible for the technical education of numerous engineering students in both the United States and Canada.

The Alumni, and three Alumnae, now totaling some 2200 members representing almost all known religous faiths is very active. Its headquarters in Halifax and branches or clubs in other cities of Canada successfully completed a drive for funds to erect a new gymnasium on the campus and construction is expected to begin during 1962. The College plans to utilize these new facilities for Convocation in May, 1963.

Sir George Williams University

Sir George Williams University has, for many years, offered a "pre-engineering"—first-year-science program. In 1957 two years were added to the existing pre-engineering year in Civil, Mechanical, Electrical, and Chemical Engineering. Graduates of this feeder program have since completed their degree work at Ecole Polytechnique, McGill, and Queen's Universities, with students presently enroled at these universities as well as at Carleton and M.I.T.

In addition to offering its day program. Sir George Williams has pioneered, in Canada, in providing the opportunity for evening undergraduates to proceed part way toward an engineering degree while fully employed. The offering of such a professional program in evening classes has been under carefully prescribed conditions. Students proceed at the rate of two calendar years for one academic year, with courses laid down in a specified pattern. The courses offered, the work required, and the examinations set, are to precisely the same standard as the day division offerings.

The first evening class completed its work last year and its members are now enroled in day classes at other universities to complete their final two years as full-time students. Only the ablest people are capable of the continuous hard work and self-discipline imposed by the evening program and consequently it is reasonable to expect that evening students completing their work in full-time day classes will rank highly.

The University is now in the process of planning new facilities in order to permit growth from its present total day enrolment, in all faculties, of 2,000 students, to a total of 5,000 day students before 1970. The expansion program includes additional facilities for honors and graduate work as well as for a full degree program in Engineering in the day division.

Present plans call for completion of the first stage of building by 1965. This will make available the necessary plant to permit offering the fourth year of the five-year sequence in the 1965-6 session, to be followed immediately by the fifth year. In consequence, the 1962-3 freshman class will be the first graduating class of the Engineering Degree program.

The curriculum will be limited initially to Civil, Mechanical, and Electrical Engineering. The present certificate program in the evening division will be retained and will in effect be a feeder program for the final two years in the day division. This built-in source of upper year students should provide a very favorable balance of numbers in upper vs lower years of the day division operation.

The history of Engineering at Sir George Williams University has been brief but we do look forward to reporting again at the 100th anniversary of the Engineering Institute of Canada.

University of New Brunswick

Instruction in engineering at U.N.B. began as the result of the foresight of two men, William Brydone-Jack and Sir Edmund Head. Brydone-Jack was appointed Professor of Mathematics and Astronomy in 1840 and served as President from 1861 to 1885. Sir Edmund Head was Governor of New Brunswick from 1847 to 1854 and Governor-General of Canada from 1854 to 1861. These men had the foresight to appreciate the significance of the technological developments of their times and their place in an academic institution. Together, they guided the institution, known until 1859 as King's College, through the most critical years of its existence. They opposed the conservative policies and classical traditions which had developed under the first President of the College who, in his Encaenial address of 1851 stated:

"In a thinly populated and comparatively uncultivated country, no means which could be employed would have the effect of filling the College with agricultural, manufacturing, mechanical, or commercial students. The attempt could have no better effect than miserable, disheartening, self-destructive disappointment. Intellectual and moral culture should be our pursuit and occupation."

Even before this time, Brydone-Jack had been giving lectures in Surveying as part of the mathematics course and was responsible for the construction, in 1851, of an observatory which boasted a six-inch telescope and was the equal of any on the continent. In 1852 Sir Edmund Head petitioned the Council of the College to consider giving specific attention to Civil Engineering. As a result, Mr. Creagan, an English engineer who was conducting a survey of the European and North American Railway to connect Halifax with Portland, gave his first lecture on February 15, 1854, to a class of 26 students; the first engineering instruction at a Canadian university. In these early years, the curriculum was heavily charged with preparation for the construction of railways.

With the transition from King's College to the University of New Brunswick in 1859, a diploma was established for the course in "Civil Engineering and Surveying" and was first awarded in 1862 to George Ketchum who, during his professional career made the first study of the Chignecto Canal. While a course in Science was established in 1871, instruction to engineering students was given primarily by the Arts Faculty, with the professional subjects given by practising engineers. The number of graduates in any year was usually not greater than five or six.

The first staff appointments to recognize the separate existence of engineering instruction was made in 1889 with the establishment of a Chair of Civil Engineering and Surveying, and the appointment of Allen Wilmot Strong as the first Professor. At the same time Dr. A. Wilmar Duff was appointed to a new Chair of Experimental Science. He was succeeded in 1893 by George M. Downing, B.Sc., an electrical engineer educated in the United States, who was appointed as Professor of Physics and Electrical Engineering.

The decade prior to 1900 is marked by an awakening of the necessity of expansion in engineering instruction, agitation for the purchase of equipment which the University could not afford and frustration of the staff, which changed frequently. The unrest of this period resulted in the establishment and awarding of the first degree in 1899 and the completion of an engineering building in 1901. Registration increased considerably following these favourable developments and it can be said that engineering education as we now understand it stems from them.

The first engineering degree was designated by B.A.I. but this was changed to B.Sc. (in Civil and Electrical Engineering) in the year 1907. The following year, John Stephens, a graduate of Trinity College, Dublin, was appointed as Professor of Mechanical Engineering. His unique personality was appreciated by generations of students until his retirement in 1945. A. Foster Baird was appointed as Professor of Physics and Elecrical Engineering in 1916 and continued as Professor of Electrical Engineering from 1927 until his retirement in 1951. Earle O. Turner came to the University from M.I.T. in 1919 and served as Professor of Civil Engineering until his retirement in 1957. There can be no doubt that John Stephens, Foster Baird and Earle Turner were the founders of the modern engineering faculty at the University of New Brunswick. Single-handedly they built up and maintained their separate departments through the lean years of the depression and into the hectic years of World War II. During this period, Electrical Engineering acquired separate facilities in the World War I Memorial Building (opened in 1924) but this was the only physical expansion.

After World War II, the veterans quadrupled the registration. Further expansion was necessary in physical plant and the staff grew rapidly. Following the veteran bulge in registration it was decided to extend the course to five years after Junior Matriculation, and to offer a degree course in Mechanical Engineering. At the same time affiliations were arranged with a number of other universities with respect to offering the first three years of instruction in Chemical and Mining Engineering. The first class from the five year curriculum graduated in 1952 and the first degrees in Mechanical Engineering were conferred in 1953.

The past 10 years have been a period of steady growth marked by a large extension to the engineering building in 1957, the beginnings and rapid growth of graduate studies, further increase in staff, increased support by the University and industry, rapid improvement of laboratory facilities and equipment and finally by the institution of degree courses in Chemical and Surveying Engineering, with the first graduates in 1962. The Surveying course is unique at English-speaking Canadian universities.

Against this background of an early start, painfully slow progress during the 19th century, gradual development under the leadership of capable, dedicated men during the first half of this century and accelerating expansion since World War II, the Faculty of Engineering at the University of New Brunswick faces the future with confidence.

University of Toronto

Engineering Building, University of Toronto.

As the 19th Century advanced, an accelerating need for the development of natural resources and an improved technology to meet domestic demands and foreign competition became apparent on the Canadian economic scene.

It was to be 1850, however, before the dire lack of men with any extensive education in practical science and technology would cause the problem to receive concrete consideration in the political and educational arena of the day. A Commission of Visitation, authorized through the Baldwin Act which became effective that year, established a chair for Civil Engineering at University College in 1851. The actual instruction for a two-year undergraduate course prescribed by the University did not become available until the 1857-58 session, and was the first complete course of study in Civil Engineering formally offered in the Province of Ontario.

Unfortunately, the inadequacy of this arrangement with regard to facilities, curricula, and qualified instruction was clearly reflected by the fact that its 26 years of existence provided seven graduates. In 1877, six years prior to the termination of this course, the Ontario Legislative Assembly approved the establishment of a professional School of Practical Science wherein its students would receive instruction from the staff in the science departments of University College for work pertaining to that of the School. The University of Toronto Senate passed a statute in 1889 to affiliate the School with the University. This was done to retain the advantage of instruction from these science departments which had since been incorporated into the University of Toronto.

A most notable appointment as Principal of the School was made in that year in the person of John Galbraith, a man of undeniable ability, courage, and integrity, — a prerequisite for those early years of controversy and struggle. His inspired leadership set the standard upon which the great traditions and esteem of engineering education at Toronto rest today; a standard which has been jealously maintained by his successors. Dean Galbraith who died in 1914, was succeeded by W. H. Ellis, 1914-19; Brig.-General C. H. Mitchell, 1919-41; C. R. Young, 1941-49; K. F. Tupper, 1949-54, and the present Dean, R. R. McLaughlin.

On December 14, 1900, the Senate established a Faculty of Applied Science and Engineering but did not assume responsibility for its support or maintenance. This tri-lateral situation between Government, University, and School of Practical Science was finally rectified in 1906 when the latter adopted its present status as the Faculty of Applied Science and Engineering of the University of Toronto.

The original three-year Diploma course was replaced in the Session 1910-11 with four years of undergraduate study leading to the degree of B.A.Sc. This had been an option since 1892 and was open to those holding the Diploma of the School. At the inception of the School, the courses of Civil, Mechanical, Mining, Assaying and Mining Geology, and Analytical and Applied Chemistry were offered. These had increased with the introduction of Electrical Engineering and Architecture by 1890, though the latter subsequently became a separate school on July 1, 1948. Today, the Faculty offers nine basic branches of engineering which include various options in the third and fourth years.

One post-war problem worth mention was handled through the operation of Ajax, 25 miles east of Toronto, as a separate and complete University community to accommodate the heavy increase of first and second year students in engineering. This staggering project involved 446 acres, 111 buildings, and a maximum registration in the 1946-47 session of 3300 students. Ajax was in existence from January 14, 1946, to May 31, 1949. New facilities in Toronto and decreased registration were responsible for its closing.

The University of Toronto Expansion Program is fulfilling another chapter to meet the demands for change and improvement in higher education. The latest engineering facilities are provided in the new Galbraith building, housing the Faculty Office, with Civil, Electrical and some Aeronautical Engineering (Institute of Aerophysics) lecture rooms and laboratories containing extensive equipment of the most modern type.

The Faculty of Applied Science and Engineering is and will be preparing for the ever widening scope and more exacting standards required for competent professional education. Engineering in particular and of necessity has been nurtured and toughened in such a climate and 12,000 living graduates of the "School" look forward with confidence to the future.

The Galbraith Building, housing Civil Engineering, Electrical Engineering, Aeronautical Engineering and the Faculty Offices. Officially opened March 7, 1961.

building which parallels the wings, while geology occupies the top floor.

A very active participant in all phases of elaboration and construction of this vast project has been an engineering graduate from the Faculty, L. P. Bonneau, who was Dean in 1960-61 before becoming Vice-Rector of the University. Through his unrelenting efforts the buildings will soon be ready for occupancy and the long expected move should be over by September 1st at the least.

Relying on its past experience and with the goodwill of its 1692 graduates, 1036 in engineering, the Faculty of Science faces the future with confidence and holds great expectations for the new phase of its life which is beginning.

University of Manitoba

The year 1962 marks the 40th anniversary of the establishment of the Faculty of Engineering and Architecture, and the 55th anniversary of formal instruction in Engineering, at The University of Manitoba, Winnipeg. In chronological order the development has been as follows:

1907 Appointment of E. E. Brydone-Jack as Professor of Civil Engineering. Beginning of formal instruction in Engineering.

1909 Establishment of Department of Electrical Engineering and appointment of Professor E. P. Fetherstonhaugh.

1913 Establishment of Department of Mechanical Engineering and appointment of Professor W. C. Rowse.

1914-18 World War I period. Students fell off in numbers until, in 1917, third and fourth years were discontinued and staff reduced.

1919 Reorganization of courses in Civil and Electrical Engineering. Appointment of Professor J. N. Finlayson as Head of Civil Engineering.

1920 Creation of separate Faculty of Engineering.

1921 Professor E. P. Fetherstonhaugh appointed first Dean of Engineering.

1922 Department of Architecture transferred from Arts to Faculty of Engineering, which became Faculty of Engineering and Architecture.

1933 Move of second, third and fourth years of Engineering from temporary quarters in downtown Winnipeg to renovated (Agricultural) Engineering building (about 57,000 square feet gross) on Fort Garry site.

1936 Resignation of Professor J. N. Finlayson and appointment of Professor A. E. Macdonald as Head of Civil Engineering.

1938 Establishment of four-year degree course in Geological Engineering, under a committee.

1939-45 World War II period, followed by large influx of veterans.

1945 Special April-September Veterans' course in first year subjects.

1946 Special January - July and April - September Veterans' courses in first year subjects. Peak registration in Engineering of 882 students. Move of first year Engineering to Fort Garry site into army temporary buildings.

1947 Re-establishment of Department of Mechanical Engineering under Professor N. M. Hall. Peak total registration in Faculty of 1217 students.

1948 Completion of one-storey (about 7,250 square feet gross) south-wing westerly extension to Engineering Building.

1949 Retirement of Dean E. P. Fetherstonhaugh and promotion of Professor A. E. Macdonald to Dean of the Faculty of Engineering and Architecture. Promotion of Professor W. F. Riddell to Head of Civil Engineering and of Professor N. A. Williams to Head of Electrical Engineering. New three-storey-and-basement (about 70,000 square feet gross) north-wing of Engineering Building completed and all years of Engineering moved under one roof for first time.

1950 Establishment of four-year degree course in Engineering Physics as option in Department of Electrical Engineering. Largest number, 244 Engineering students to graduate at one time.

(Continued on page 96)

Month to Month

JOHN STANLEY WADDINGTON, M.E.I.C., Vice-President of Phillips Electrical Company Limited, has been elected a Vice-President of the Engineering Institute of Canada. Mr. Waddington graduated from the University of Manitoba in 1934 with a B.Sc. degree. He became a member of the Institute in 1947. Since then, he has participated in many Institute activities. He was a Councillor from 1957 to 1961; Chairman of the Professional Interests Committee, 1958, and Chairman of the Committee on By-laws, 1959-1962. Mr. Waddington was Chairman of the Brockville Branch in 1954. He is a member of the Brockville Public Library Board and a Member of the Board of Governors at the Brockville General Hospital.

GEORGE DEMERS, M.E.I.C., Consulting Engineer of Montreal, has been elected a Vice President of the Engineering Institute of Canada. Mr. Demers graduated from the University of Montreal, Ecole Polytechnique, and completed post-graduate work at Ecole Nationale des Ponts et Chaussees, Paris, France. Mr. Demers is a member of several technical societies including the Society of Civil Engineers, the American Water Works Association and the Canadian Institute of Sewage and Sanitation. Mr. Demers was chairman of the Quebec Branch in 1948, and was a Councillor of that area.

John B. Mantle, M.E.I.C.

John James Rowan, M.E.I.C.

JOHN B. MANTLE, M.E.I.C. Professor and Head of the Mechanical Engineering Department at the University of Saskatchewan has been elected a Vice President of the Institute. Professor Mantle graduated with a B.E. degree in Mechanical Engineering from the University of Saskatchewan in 1941, and with a M.Sc. from the University of Illinois in 1947. He was a student member of the Institute in 1941, an Associate Member in 1943, and became a full Member in 1946. Professor Mantle was Councillor for Saskatchewan in 1956 and 1957. He was Secretary-Treasurer of the Saskatchewan Section, 1947-48; member of the Branch Executive, 1949-50 and 1962; Saskatchewan Branch Vice Chairman, 1958; Chairman, 1959; Chairman of the Papers Committee, 1959 Western Technical Conference; Faculty Advisor, 1957-62. Professor Mantle is active in the A.P.E. Sask., and the Kiwanis Club. He has had several papers dealing with stress analysis published, and was stress analysis consultant to the Dominion Government P.F.R.A. and Saskatchewan Power Corporation.

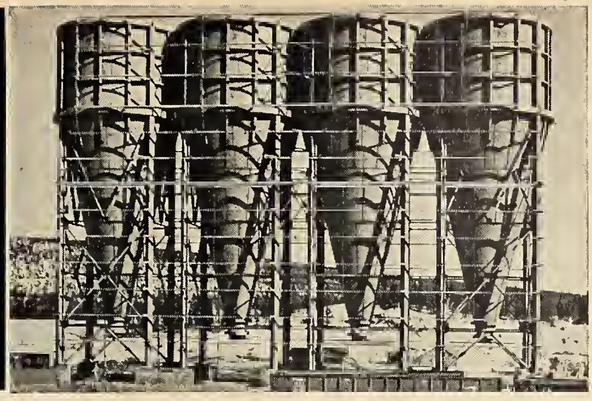
JOHN JAMES ROWAN, M.E.I.C., Refinery Manager at Imperial Oil Limited, has been elected a Vice President of the Institute. Mr. Rowan graduated with a Bachelor's degree in Civil Engineering from Ecole Polytechnique in 1935, and in Mechanical Engineering from M.I.T. in 1936. He attended the Advanced Management Program at Harvard University in 1955. Mr. Rowan was Program Chairman of the Sarnia Branch in 1951, and Vice Chairman of the Branch in 1952-53. His outside activities include executive positions in several charitable organizations. Mr. Rowan was Chairman and Consultant of the Remuneration Committee of the C.P.E., and Past Chairman of the Laval Industrial Association.

STANLEY J. CAREW, M.E.I.C., Dean of the Faculty of Applied Science at Memorial University of Newfoundland, has been elected a Vice President of the Institute. Mr. Carew graduated from Dalhousie University in 1936 with a B.Sc. degree, and from Nova Scotia Technical College in 1938 with a B.E. He was Chairman of the Newfoundland Branch in 1954-55. He was President of the A.P.E. of Newfoundland in 1957-58. Mr. Carew is active in community affairs. He is Chairman of the Provincial Apprenticeship Board of Newfoundland, a Member of the Canadian Services Colleges Advisory Board, and a Member of the Nova Scotia Technical College Senate.

George E. Humphries, M.E.I.C.

Stanley J. Carew, M.E.I.C.

GEORGE E. HUMPHRIES, M.E.I.C., President of M. M. Dillon and Company, Ltd., London, Ont., has been elected a Vice President of the Engineering Institute of Canada. Mr. Humphries graduated from Wolverhampton Technical College with a Diploma in Mechanical Engineering in 1931. He was a student member of the Institute in 1930, and became a Full Member in 1943. He was secretary of the London Branch in 1950, and Chairman in 1951. He was Councillor in 1957-58. Mr. Humphries is also Vice President of Consulting Engineers of Canada.



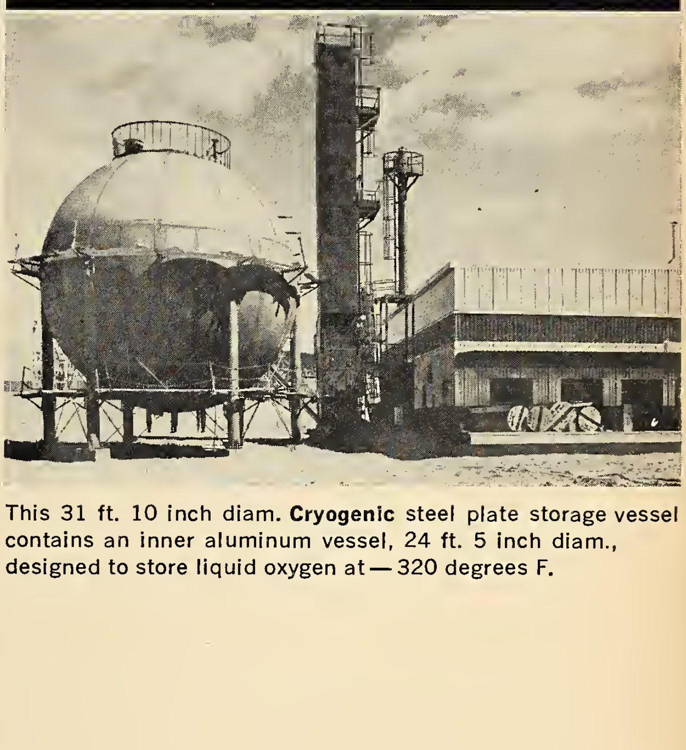
These concentrate load-out bins are 33 ft. in diameter and are constructed in heavy gauge steel plate.

Horton engineers steel plate for Newfoundland Iron Ore Mine

The rugged, large scale engineering demands of iron ore mining are typical of the numerous heavy gauge steel plate fabrication requirements met by Horton.

At the Iron Ore Co.'s mining location at Carol Lake, Newfoundland, Horton has fabricated and field-erected the steel plate for a battery of ore load-out bins and a Cryogenic liquid oxygen storage vessel. These two widely differing structures demonstrate Horton's ability to form or shape any type of steel or other metal, in any gauge, to any specifications, anywhere in Canada!

Horton has the engineers, the facilities and the experience to develop *the* answer to *your* steel plate problems, large or small, no matter where. If your requirements can be met in fabricated steel plate — call Horton today.



This 31 ft. 10 inch diam. **Cryogenic** steel plate storage vessel contains an inner aluminum vessel, 24 ft. 5 inch diam., designed to store liquid oxygen at — 320 degrees F.

HSW-6210

CISC

HORTON SHAPES NEW HORIZONS

HORTON STEEL

WORKS, LIMITED

25 ADELAIDE STREET WEST, TORONTO, ONTARIO

Plants and Offices throughout Canada

TANKS AND STEEL PLATE WORK FOR ANY INDUSTRIAL ASPECT . . . IN CARBON STEEL, SPECIAL METALS OR COMPOSITES

Personals

W. A. Hepburn

J. B. Christensen

Willian A. Hepburn, M.E.I.C. (Purdue '42) has been elected Chairman of the Steel Industries Advisory Council, the co-ordinating agency of all segments of the steel industries serving construction in Canada. Mr. Hepburn is Vice President of John T. Hepburn, Limited, Toronto and a Past President of the CISC of which he is now a director.

Jorgen B. Christensen, M.E.I.C. (Engrg. Coll. Horsens, Denmark) has been appointed a Marine Engineer with McNamara Engineering Limited, Toronto. Mr. Christensen, formerly a Senoir Engineer with C. D. Howe Co. Ltd., Montreal, has had ten years' experience on various engineering projects in the Baie Comeau, Seven Islands and Shelter Bay area in Quebec, and at Wabana, Newfoundland. Kalju Ojala has been appointed a municipal engineer with McNamara. Mr. Ojala, a graduate of the University of Toronto, has had eight years experience in the design of municipal engineering projects throughout Ontario.

George H. Crase has been appointed Vice President of Sales at Horton Steel Works, Limited, Toronto. Mr. Crase's experience with Horton extends over a period of 17 years in a contract engineering capacity.

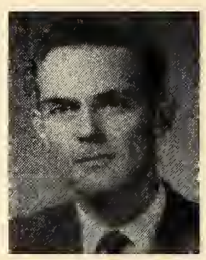
G. H. Crase

S. B. Moro

Orby Brumell, M.E.I.C. (McGill '34) has been appointed President and General Manager of Separator Engineering Manufacturing Ltd. In his new position Mr. Brumell will be responsible for Separator's world-wide manufacturing affiliates as well as the domestic facilities. Mr. Brumell is president of St. James Reality Co. and a director of numerous other Canadian corporations. He is a Past President of the John Howard Society, Divisional Chairman of the Welfare Federation Campaign, and a member of the Executive Committee of the Canadian Manufacturing Association.

Gerald A. McFaden has been appointed Technical Officer of the Canadian Institute of Timber Construction. He will be located in Ottawa. His experience prior to joining C.I.T.C. includes the construction, timber preservation and glued-laminated timber industries.

O. Brumell



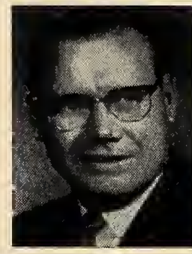
G. A. McFaden

G. L. Osberg, Head of the Chemical Engineering section, Division of Applied Chemistry, National Research Council, Ottawa, has been appointed Editor of the Canadian Journal of Chemical Engineering, published by the Chemical Institute of Canada.

Major D. G. McClellan, an officer in the Royal Canadian Engineers, has been appointed Canadian Liaison Officer in the office of the chief engineers at Fort Belvoir, Va.

S. B. Moro, M.E.I.C. (Queens '45) has been appointed refinery manager of Shell Oil Company's new Oakville refinery. Mr. Moro was formerly manager-construction. In his new capacity, he will continue to direct the building of the Oakville refinery which is scheduled for completion early next year. As refinery manager, he will also be responsible for organizing, manning, commissioning and operating the refinery.

R. E. Tweeddale



S. M. Young

R. E. Tweeddale, M.E.I.C. (U.N.B. '35) General Manager of the New Brunswick Electric Power Commission, Fredericton, has been elected President of the Canadian Electrical Association. Mr. Tweeddale, who was a district highway engineer in New Brunswick from 1935 until his enlistment in the R.C.A.F. in 1940. He then served overseas as a radar officer until 1945. He joined New Brunswick Electric Power Commission in 1945, and eventually became first general manager in 1958. Mr. Tweeddale served with the International Joint Commission in 1952, on the study of the St. John River basin. In 1960, he was chosen Canada's Electrical Man of the Year for leadership in completing the New Brunswick-Nova Scotia power grid.

Stephen M. Young has been elected a Director of International Harvester Company of Canada. Mr. Young joined the company in 1935 after graduating with a degree in Mechanical Engineering from the University of Saskatchewan.

Charles M. Thomson has been appointed Vice President and General Manager of Railway & Power Engineering Corporation, Limited. In his new capacity, Mr. Thomson will be responsible for the operation of this sales and and distribution organization.

L. D. Baldwin has been named manager of the Halifax Branch of Burroughs Business Machines Ltd. Mr. Baldwin joined Burroughs in 1950 as a sales representative and has since held responsible positions in Toronto and Hamilton. In 1958 he became zone sales manager in Toronto. **Richard R. Bruce** has been appointed to the newly created position of employment supervisor for Burroughs. Mr. Bruce will co-ordinate recruiting efforts at Toronto Head Office with branches of the company across the continent.

C. A. Blue

Charles A. Blue has been appointed sales manager for FWD Corporation (Canada) Ltd. In his new position, Mr. Blue will be responsible for all sales activities of the company throughout Canada. Mr. Blue was formerly associated with Allis-Chalmers Mfg. Co.

James S. Carlile has been appointed Vice President of Electronics Corporation of America (Canada) Ltd., and **Douglas C. Appleton** has been appointed Secretary of that company. Mr. Carlile has extensive experience in the field of combustion control and industrial instrumentation and has been Manager of this company since its inception in Canada. Mr. Appleton is controller for the company. He has had wide experience in the management accounting field.

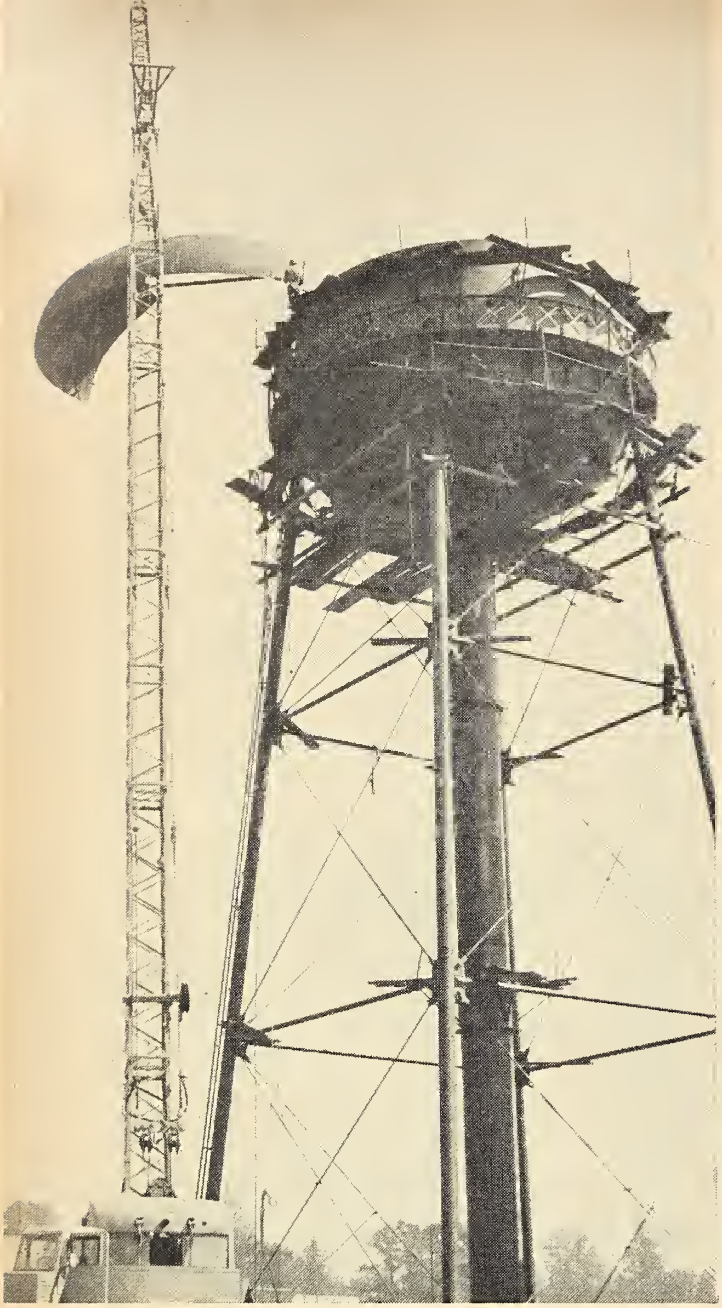
D. C. Appleton

J. S. Carlile

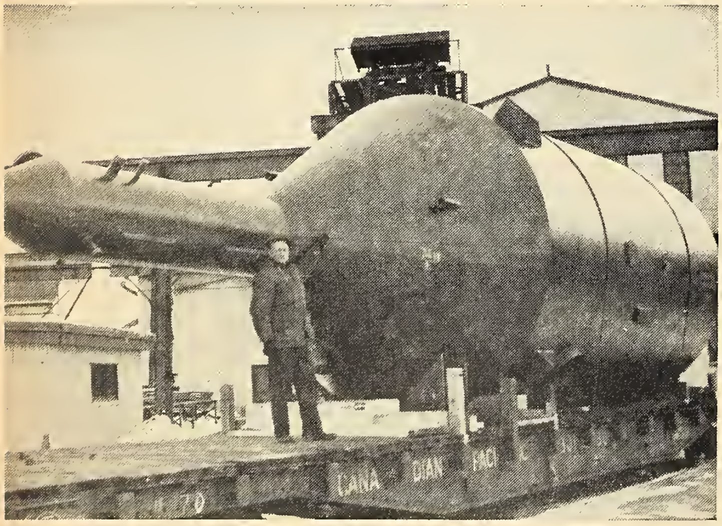
Frank G. Huck has been appointed controller of three Canadian operating companies of the Bowater Corporation. These are the Newfoundland Pulp and Paper Mills Ltd., at Corner Brook; the Bowater Power Company Ltd., at Deer Lake; and Bowaters Mersey Paper Company Ltd. Mr. Huck will have headquarters in Corner Brook.

Taylor J. Kennedy, M.E.I.C. (McGill '39) has been appointed Assistant to the President of the Canada Cement Company. He joined the company in 1940 as Plant Engineer at the Montreal East plant, and was Project Engineer, then Superintendent at Plant 1 from 1945 to 1955. He was then transferred to the Head Office as Superintendent of All Manufacturing Plants, and became general superintendent in 1958.

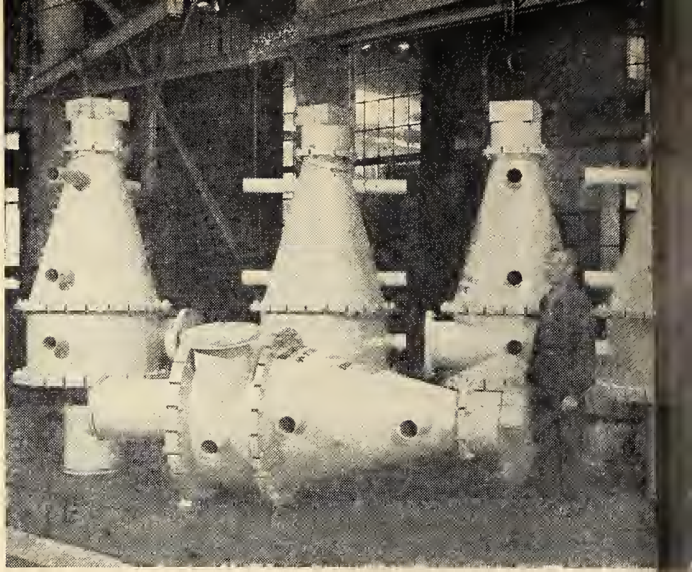
L. D. Baldwin has been named manager of the Halifax Branch of Burroughs Business Machines Ltd. Mr. Baldwin joined Burroughs in 1950 as a sales representative and has since held responsible positions in Toronto and Hamilton. In 1958 he became zone sales manager



Dominion Bridge construction crews at our Vancouver branch hoist last segment of 100,000-gallon water tank. The tower is 102 ft. high and 28 ft. 8 ins. in diameter.

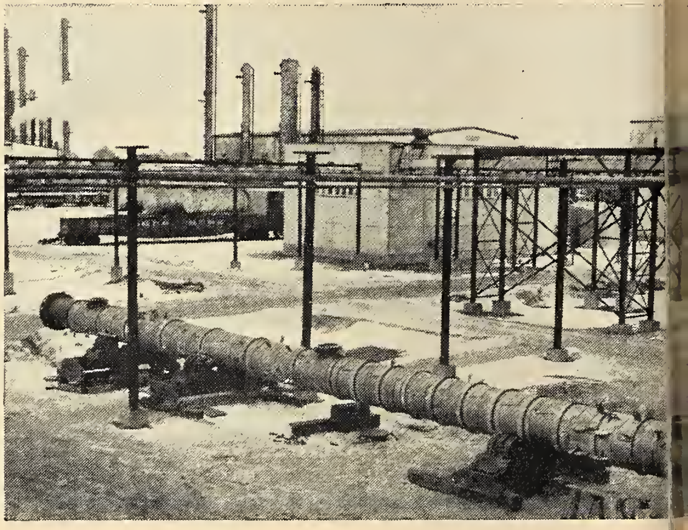


One of 4 evaporators used in the salt industry leaving the Manitoba Bridge plant in Winnipeg. Each unit is 47 ft. in length and weighs 33 tons.



"Cyclone" thickeners for use in centrifugal separ of fine and coarse aggregates in the mining indu Twenty-four of these 36" diameter thickeners an smaller 14" diameter units were built in Montre Quebec Cartier Mining Company.

Five of nine 340-barrel closed fermenting tanks fabric at Manitoba Bridge in Winnipeg for Bishopric Prod Company, Cincinnati. Each tank weighs 8 tons.



This 80-ft. long 36-inch diameter, stainless steel to was fabricated in Edmonton for an Alberta pe chemical plant. Weight of the vessel is 22,000 pounds

Other Societies

SHELL STRUCTURES

Photographs of permanent shell structures in Canada have been urgently requested for display at the World Conference on Shell Structures. This Conference will be held this year in San Francisco during the first week of October.

At the Conference each country will be assigned a panel on which to display a sample of its shell structures. The most desirable photographs will be mounted, and should emphasize some of the architectural and structural features of the structures.

Engineers, architects or others who may have such photographs, and who wish to have them considered for display at this important Conference, are asked to submit them to: Professor M. P. Lafreniere, 820 Westmount St., Sherbrooke, Que.

AEROSPACE SUPPORT

One of the principal aims of the International Conference and Exhibit on Aerospace Support will be to inform the public of the significance of this large phase of the space program. Aerospace support is concerned with the preflight checking and readying, in-flight monitoring, and landing or recovery phases of aerospace vehicles. More than 70 per cent of total program expenditures for missile programs has been on the support aspects.

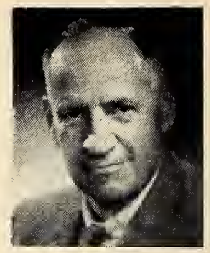
The other principal aim of the program is the precipitation of a nucleation on an international basis of all related work in the field towards advancing the state of development in the aerospace support area.

The Conference will appeal to nearly every engineering discipline, particularly electrical and mechanical. It will be held in the Sheraton Park Hotel, Washington, D.C., August 4-9, 1963.

COLUMN RESEARCH COUNCIL

The Column Research Council has recently established a special committee under the chairmanship of Professor R. A. Hechtman of the Department of Civil Engineering, George Washington University, Washington, D.C., to assist in the interchange of information on experimental methods in the study of structural stability. The committee is soliciting memoranda and reprints of papers from experimental workers in every country describing test procedures they have used or devised.

By this notice, workers in these fields in Canada are requested to communicate with Professor Hechtman regarding their test procedures. It is to be noted that the survey is to embrace studies of plates, shells, and beams, as well as studies of column members. Both static and dynamic or impulsive loading conditions are of interest. Procedures for analysing test data are also to be included in the study.



Dwight D. Simmons

C.C.P.E.

Dwight D. Simmons, a Director of Imperial Oil Limited, Toronto, has been elected President of the Canadian Council of Professional Engineers. Mr. Simmons, who was President of the Association of Professional Engineers of Ontario in 1960, was elected during the C.C.P.E. Annual Meeting in Quebec City in May.

Other officers elected at the meeting were: Gilles Sarault, Quebec City, Vice-President; and J. F. McDougall, Edmonton, Member of the Executive.

ENGINEERING MANAGEMENT

The 10th Annual Joint Engineering Management Conference will be held in New Orleans, La., September 13-14. The Conference will be divided into four one-half-day sessions.

The first session, "The Challenge of the Future", will include a review of the contribution engineering and science has made to our modern society, and a look ahead to the developments anticipated in the near future. This will include a reeognition of new sets of conditions created by industry dispersal and the economic development of Latin America.

The luncheon speaker on Sept. 13 will be C. H. Shumaker, Southern Methodist University, Dallas, Tex., President of the American Society of Mechanical Engineers. His topic will be "A Philosophy for Management."

Session II, "Engineering Education", will deal with the changing patterns in undergraduate engineering curricula and programs for the continuation of an engineer's education after graduation.

To be discussed at Session III, entitled "Managerial Contribution to Engineering Work," will be the organization of engineering work, motivation, wage administration, and the development of a creative engineering environment.

At the Sept. 14 luncheon the guest speaker will be Ambassador de Lesseps S. Morrison, U.S. Representative on the Council, Organization of American States. His topic will be "Latin America —Key to the Future."

The final session, entitled "Contributions by Engineers to Managerial Work," will deal with the contributions engineers have made and may be expected to make in the fields of automation, mechanization and the control of reliability of functions.

ALL ENGINEERS

To improve its service to you, The Engineering Journal has installed the most modern electronic data processing equipment available.

To take full advantage of this modern equipment it is necessary to obtain from you up-to-date information.

To assist in obtaining the most accurate information possible, all engineers receiving The Engineering Journal have been sent a questionnaire on which they are asked to supply the pertinent data.

There are two basic reasons why it will be to your advantage to complete and return this questionnaire as promptly as possible.

1. The combination of accurate information and high-speed data processing equipment will result in a much-improved circulation service. This will be especially helpful in dealing wtih changes of address, which now number about 1,000 a month.
2. The more precisely that a reader's primary field of technical interest is known, the more closely it will be possible to cater to this interest.

TO MEMBERS OF THE ENGINEERING INSTITUTE OF CANADA, even greater dividends will be apparent through a more intensive program of supplying specific information through publications and conferences.

SHOULD YOUR QUESTIONNAIRE HAVE BEEN MISLAID, the Circulation Manager of The Engineering Journal, at 2050 Mansfield St., Montreal 2, will be pleased to send you a replacement.

Branch News

A.S.E.E.

The new United States Air Force Academy at Colorado Springs was the site of the 70th Annual Meeting of the American Society for Engineering Education held June 18 to 22. More than 1000 leaders of American engineering education attended, as well as 18 delegates from Canada. Divisions of the Conference included Aeronautical Engineering, International Engineering Education, Engineering Graphics, Technical Institutes and Engineering Education.

A discussion of American participation in engineering education in foreign countries was presented by the chief university co-ordinator for the United States Peace Corps. Several leaders in international engineering education outlined phases of the American aid program in this field, and pointed out the necessity for augmenting it. Since most under-developed countries lack adequate engineering schools, their greatest need is for practical engineers, new buildings, and staff.

A general session devoted to biomedical engineering included discussions from the development of space suits to the investigation of various types of safety glass for windshields.

A meeting on engineering ethics was held and the progress on a case-book of ethical problems was described. Delegates expressed strong interest in the Canadian engineers' iron ring ceremony, and several leaders advocated the adoption of a similar rite in the United States.

Outstanding engineering educators were presented with awards at the closing banquet.

CENTRAL B.C.

A. F. Joplin

One of the outstanding events in the 1962 program of Branch activities took place June 1 when the members and their guests from the Vancouver and Victoria Branches participated in an inspection field trip through the Rogers Pass area of the Trans Canada Highway. Ian Stewart, District Engineer with the Provincial Department of Highways at Revelstoke; R. D. Coates, of the Public Works Department at Revelstoke, and A. F. Joplin, Division Engineer with C.P.R. organized this trip.

The party travelled in a car convoy over Rogers' Pass. Drivers were briefed and provided with maps indicating the locations of works of interest, as well as areas from which photographs could be taken. Inspections were made of the snowsheds constructed at the western entrance of Glacier Park by the Provincial Government, and at Rogers' Pass by the Federal Government.

A complimentary lunch for the 75 engineers present was served at McNamara Construction Company's camp at Stoney Creek. Following this, the group travelled through the Donald Crossing of the Columbia River, the last major crossing on the Trans Canada Highway.

On the return journey, the group was taken to the lookout on Mount Revelstoke where a marked map was erected showing the area to be flooded by High Arrow Dam.

A dinner meeting was held that evening at the Chalet in Revelstoke. R. B. Styles, Superintendent of Glacier and Revelstoke National Parks, and R. Pittaway, Chief Warden, spoke on the organization of the National Parks.

The Canadian delegation to the Congress of the International Institute of Welding held recently in Oslo, Norway, was headed by R. M. Gooderham, Manager of the Canadian Welding Bureau, and Member of the Governing Council of the I.I.W. Five Canadian engineers participated in Commissions studying various aspects of welding. Dr. K. Winterton of the Department of Mines and Technical Surveys, served on Commissions concerned with the behaviour of metals subjected to welding and residual stresses and stress relieving. John Hayward, of Dominion Bridge Company, Limited, Edmonton, was concerned with Commission for the testing, measurement and control of welds and the commission dealing with pressure vessels, boilers and pipelines. Dr. Choquet, an expert on Fatigue at Ecole Polytechnique in Montreal, worked with the Commission on Fatigue Testing and in conjunction with Dr. Winterton. J. Royer, President of Welding and Supplies Limited, Montreal, represented Canada on the Commission dealing with Gas Welding and that concerned with special arc welding processes. Mr. Gooderham acted on Commissions dealing with education and the fundamentals of design and fabrication.

More than 700 delegates from 25 countries attended this Congress.

HAMILTON

George D. Mahon

The Professional Development Program sponsored by the Engineering Institute of Canada, has been active in Hamilton since 1951. The objective of this program is to stimulate the engineer's interest and understanding of topics outside his chosen field.

The Hamilton Branch extends a special invitation to engineers in the Hamilton area, to attend the courses which started this month. During the years, the activities and scope of the program have been expanded and improved, and now, a four-group graded program is in operation.

While the program is designed for engineers, other interested professional people such as architects and those allied to engineering are invited to inquire to the program director. Registered engineers will be contacted by mail. Senior engineers are invited to participate and contribute their experience. Inquiries should be directed to the Program Director, Mr. G. W. Neal, 516 Lynda Lane, Ancaster, Ont.

Meetings of Special Interest to E.I.C. Members

OCTOBER 22-24
Joint CIC-EIC Chemical Engineering Divisional Technical Conference at Sarnia

FALL OF 1962
Newfoundland Regional Conference

EARLY DECEMBER 1962
Northwestern Ontario Regional Technical Conference at Fort William

FALL OF 1963
St. Maurice Valley Regional Technical Conference at Grand'Mere

Library Notes

Prepared by the Library, The Engineering Institute of Canada

Book notes marked by an asterisk have been provided through the courtesy of The Engineering Societies Library in New York.

BOOK REVIEW

DESIGN OF WATER-RESOURCE SYSTEMS.

Sub-titled "New techniques for relating economic objectives, engineering analysis, and governmental planning", this study investigates the engineering, economic and political aspects, and discusses possible solutions and new methods for handling the problems which arise. (Arthur Maass and others. Cambridge, Harvard, Toronto, Saunders, 1962. 620p., $15.00.)

STRENGTH OF MATERIALS, 3RD ED.

An undergraduate text, the aim of this volume is to provide an understanding of the principles of engineering design, and indicate the shortest analysis of a variety of problems. New examination questions have been added. (G. H. Ryder. London, Cleaver-Hume, 1961. 340p., 24/-.)

***RIPPLE TANK STUDIES OF WAVE MOTION.**

The study of ripple patterns on a water surface is helpful in understanding other forms of wave motion. This work describes improvements which make possible a reliable interpretation of the finer details in photographs of a pattern of surface waves on a liquid. (W. Llowarch. Toronto, Oxford, 1961. 66p., $2.25.)

***COLD FORGING OF STEEL.**

The practical aspects of cold forging are covered. Theory is presented only for the relatively simple backward and forward extrusion operations. (H. D. Feldmann. London, Hutchinson, 1961. 268p., 40/-.)

***THE THEORY OF SUBSONIC PLANE FLOW.**

This is a systematic treatment of two dimensional subsonic, inviscid fluid motion and its aeronautical applications. Included is an extensive account of mixed boundary-value problems. (L. C. Woods. Toronto, MacMillan, 1961. 549p., $20.50.)

DISTILLATION: PRINCIPLES AND DESIGN PROCEDURES.

Although not intended to be an exhaustive literature survey, this volume does contain extensive bibliographies. It presents all the information needed for the design of a distillation column, emphasizing the principles of distillation and design procedures. (R. J. Hengstebeck. New York, Reinhold, 1961. 365p., $11.50.)

***PROFITABLE USE OF EXCAVATION EQUIPMENT.**

This is a textbook being used for the courses in open-pit mining, equipment and equipment systems research in the Mining Department at the University of Arizona. Although not intended to be used as a "manual" for estimating bid costs, the fundamentals as set forth are considered very valuable for the purpose. (E. R. Drevdahl, Tucson, Desert Laboratories, 1961. Various pagings, $10.00.)

***LE CALCUL PRATIQUE DES CONSTRUCTIONS A INERTIE VARIABLE.**

This treatise on theory and applications of a practical method of analysis for hyperstatic structures of variable inertia includes a large collection of tables and charts. Numerous examples help in determining the easiest approach to the tables and the proposed methods. (Pierre Charon. Paris, Eyrolles, 1961. 777p., NF 150.85.)

THE ENGINEERING INSTITUTE LIBRARY

The publications mentioned in these notes are now available in the Library and may be borrowed by members of the Institute. Two items may be borrowed at one time for a period of two weeks, excluding time in transit.

Library hours are: Monday to Friday: 9 a.m. to 5 p.m. All requests and enquiries should be addressed to the Librarian at 2050 Mansfield Street, Montreal.

***SCREW THREADS—DESIGN, SELECTION, AND SPECIFICATION.**

Detailed information is provided on the design, selection, and specification of all types of screw threads, including those used for motion translating and power transmission. The book ranges from basic design considerations to the more complex situations involving fasteners, translating screws, nuts and tapped holes, and special threaded components. (R. V. MacKenzie. New York, Industrial Press, 1961. 198p., $10.50.)

***LINEAR SIGNAL-FLOW GRAPHS AND APPLICATIONS.**

Written on a level suitable for beginning students, this monograph presupposes a knowledge of simple electronic circuits and basic manipulation rules in matrices and determinants. (Yutze Chow and Etienne Cassignol. New York, Wiley, 1962. 144p., $6.95.)

SEMICONDUCTOR ABSTRACTS, VOL. 7, 1959.

The 3,127 abstracts in this volume refer primarily to papers which appeared during 1959, although some papers published earlier are included. This is the last volume to be published in this series, which has been sponsored by the Electrochemical Society, and compiled by the Battelle Memorial Institute. (J. J. Bulloff and C. S. Peet, eds. New York, Wiley, 1962. 714p., $20.00.)

KEMPE'S ENGINEERS YEARBOOK, 67TH ED., 1962.

In this edition the index has been revised, the chapter on flow metering and mechanical testing enlarged and made into two, the chapters on clays and mortars and cements revised and combined in one chapter. Additional information has been included. (Ed. by C. E. Prockter, London, Morgan, 1962. 2 vols., 95/6.)

***OPERATIONS RESEARCH IN PRODUCTION AND INVENTORY CONTROL.**

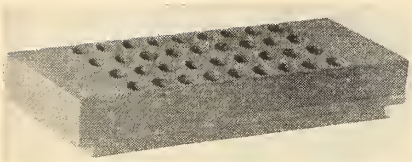
The mathematical theory and the applications of this theory to a variety of actual inventory problems is developed in a systematic treatment. The bibliographies are extensive and refer to both mathematical details and additional applications. (Fred Hanssmann, New York, Wiley, 254p., $8.95.)

(Continued on page 91)

Business and Industrial Briefs

Developments

Information contained in this section has been obtained from press releases. Mention of products and services does not imply endorsement by the Institute.

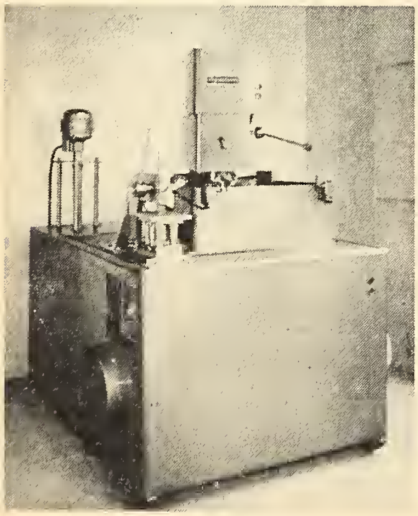


New Suction Box Covers

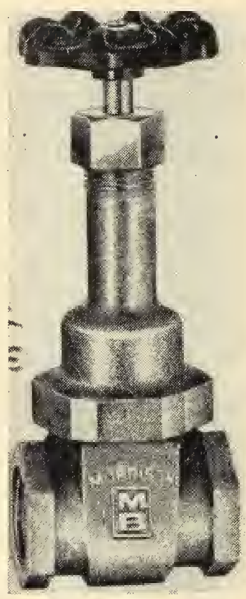
THE REACON TESTER, an instrument for the rapid determination and control of reagent concentration in leach liquors and pulps, has been introduced by Measurement and Control Engineering Limited, Scarboro, Ont. The instrument is for use primarily in leach plants where metal is extracted from ore. It measures and records concentration as well as adjusting the rate at which the reagent is added to the slurry in order to keep the conductivity constant. The probe is essentially maintenance-free as the electrical components are completely isolated from the fluid being analyzed. There is no need to filter the slurry. The electrical controls are mounted in a sealed cabinet which protects the unit from corrosive fumes. The entire instrument is temperature compensated and has a sensitivity of .05 grams/litre of lime to a cyanide solution or .5 grams/litre of caustic soda to an alkaline solution.

ATLAS COPCO Canada Ltd. has introduced a new process for sharpening rock drill bits and integral drill steels. The process, known as "Copcotron", uses spark erosion. The chief components of the system are: a form-fitting electrode, a servo system, a motor, a pump and an oil tank. To operate, the rack of bits is positioned with cutting faces close to the form-fitting electrodes; both inserts and electrodes are immersed in an oil bath. When the power comes on, the spark-erosion process begins.

The Copcotron



THE JAMES MORRISON Brass Manufacturing Co. Ltd., has developed a new bronze rising spindle gate valve for the plumbing, heating and industrial trade. The solid wedge type valves are recommended for pressures of up to 125 lb. saturated steam or up to 200 lb. for non-shock cold water, oil or gas. Constructed to withstand pressure and piping strains, they are precision-produced in sizes ½ inch to 3 inch.



Rising Spindle Gate Valve

A NEW COMPOSITION of polyurethane for use by the pulp and paper industry for suction box covers has been announced by Pulp & Paper Mill Accessories Ltd. The high-impact material, "LFT 4", has low .030 coefficient of friction, excellent abrasion resistance, hardness of 75 on the Shore D scale and dimensional stability preventing any distortion under normal operating temperatures. "LFT 4" does not require reinforcement. It possesses very good machining properties and can be resurfaced by equipment currently in use.

ERRATA

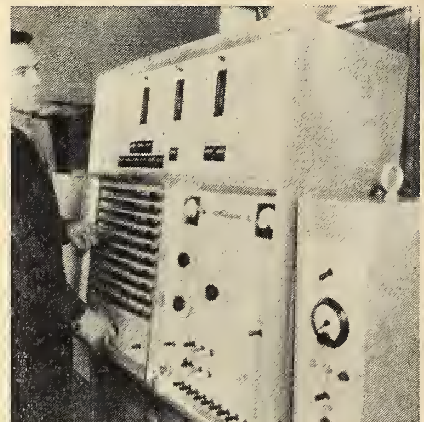
In the May issue of the Engineering Journal it was reported in error that **David Brown (Canada) Limited** of Toronto had introduced a series of silicone/aluminum paints. David Brown (Canada) Limited manufacturers agricultural tractors and machinery. We regret this error and apologize for any inconvenience or embarrassment it may have caused.

Machine Time Calculators

MACHINING TIME CALCULATORS which provide a simple method for determining consistent machining times has been announced by Manresa Developments Corporation, Montreal. Because of their ease of operation, the calculators are ideal for determining the efficiency of machine operation. Each calculator is in the form of a circular slide-rule which incorporates a section to determine the actual cutting time; a section to provide setting-up time; and other sections to determine the loading and manipulating times.

THE FIRST electronically controlled concrete batching plant in British Columbia is now in operation at Deeks McBride's Main Street facility, Vancouver. The modernized plant is remotely controlled from an adjacent tower by an electronic batching console. The operator selects from pre-set formulas and remotely controls batching and dumping cycles, moisture compensation, batch proportion and other operations. The plant produces concrete maintaining exact formulas from batch to batch. EIC

Batching Plant



THE LEARNED SOCIETY — THE LIFETIME UNIVERSITY

Glenn B. Warren, Pesident of the American Society of Mechanical Engineers, at an address in St. Louis at the Semi-Annual Meeting in 1959, stated that ". . . a professional man is one with a special body of knowledge and understanding toward which he feels three compulsions: to use it in the public interest, to add to it by his own efforts, and to teach this knowledge and understanding to his contemporaries and to the coming generation".

"These are the characteristics which have always set the professional man off from the business man, the tradesman and the worker. Society will not long withhold its recognition of our position when the majority of engineers live up to these compulsions. We have the obligation to do so.

"Active participation in all phases of a professional engineering society's activities . . . is one of the most effective the individual engineer has of implementing his obligation and realizing his opportunities."

Referring to the seething political unrest and longing for a better life and health on the part of the world's underprivileged billions, Mr. Warren drew attention to the great opportunities and obligations before the engineer, noting:

"In this conflict all our instincts, desires and prayers are for a peaceful world in which we can turn our talents, training and experience toward making this world a better place for men of all nations to dwell. But if the future holds a continuation of the struggle for existence and the survival of the fittest on a national scale, the engineer's obligation is clear, to exert the utmost effort to see that the forces of freedom and the civilization of the west are enduring — and rest assured that, unless the diplomats and statesmen can avert the conflict, the results will depend on the results of our contest in the field of science and engineering.

"An obvious imperative is to give more attention to the excellence and adequacy of our children's and our grandchildren's education, not only along scientific, but cultural, economic and sociological lines as well. We need to see these youngsters are all challenged to the limit of their ability, but particularly we should see that those with talent — children of whom much is to be expected — are encouraged and challenged to the limit of their capacity.

"We engineers should know that the current problem of insufficient teachers, insufficiently trained teachers, and underpaid teachers, can only be solved by the same engineering techniques by which these same problems have been solved in the factory, on the farm, in the mine, in the oil field; namely by giving the workers — in this case, the teachers — better tools so as to increase their effectiveness. This means more modern buildings, better books, effective and adequate educational TV, and educational movies whereby whole courses are taken over by these modern aids, but with the teacher's help, co-operation and leadership. We know these techniques have worked before. They can be made to work here. We engineers can help."

Recently the ECPD Committee on Development of Young Engineers called attention to the need for after-college professional development of the young engineer, stating:

"Engineers are costly for society to produce. They are expensive to maintain. Their output is important to our continued growth, to our high standard of living, and in these times, particularly, to the safety of our country. It is most important that this valuable resource be used to its maximum.

"The process by which a young engineer is effectively fitted to a job can be a short one or a long one but, in any case, it involves three steps: (1) finding the job, (2) learning the job, and (3) growing in the job.

"Finding the right job needs attention. Because of the rapid development of science the problems of adapting a particular capability to a particular task, both of which are changing rapidly, is formidable. Learning the job after one gets it may be routine but keeping up is not. Someone has said that the half-life of an engineer's education is 15 years. If this is true, the technical deterioration of a man's education is at the rate of 3% a year. If we are not to lose this technical capability, a constant effort must be made to keep our people abreast of the times and also working on those jobs for which they continue to be best fitted. This effort must not be left to chance or made exclusively dependent on good motivations or the judgment of our young engineers, but it must also be purposely planned and purposely fostered by responsible executives in industry, professional organizations and colleges."

Recently, in "A Challenge to Engineering Management", by G. A. Hawkins, Dean of Engineering at Purdue University, which was published in Mechanical Engineering for November, 1959, Dean Hawkins said:

"During the period of from one to approximately five years after commencement, young men often feel that their programs of study should have included much more in the way of practical courses such as drafting, skill in programming and so on. With a foundation of this type, they feel they could have started off immediately solving the day-by-day problems confronting them in industry.

"The second group consists of those who have been out of college five to 15 years. These graduates feel that they should have had many more courses in mathematics, physics, chemistry, and the engineering sciences, as they need this type of information for solution of difficult engineering problems.

"The third group, having been out of school 15 to 25 years, have become engaged in management and administration. In expressing their opinions, they feel that they should have been given many courses in organization, public speaking, labor relations, finance, life insurance, retirement programs, budgeting, stocks and bonds, and investments.

"The fourth group consists of those who have been away from college for approximately 25 years or more. Those in this class who return appear very disappointed that few of their courses were devoted to the fine arts, music, literature, grammar and foreign cultures. These are the areas in which they feel deficient when talking to their contemporaries and when travelling.

"It would not be possible for an engineering student to acquire, in a four or five-year program, a knowledge of present-day practice, a strong foundation in the engineering and physical sciences, a broad education for management, and an appreciation for the arts, literature, and music.

"Those engineering graduates who adopt a philosophy of lifelong learning during the course of their professional career, ultimately acquire this type of total education. — I fear that many of those who complain have not chosen to regard learning as a lifelong process, and that they are not or have not been willing to put forth the necessary effort required by the adoption of such a philosophy.

"One of the most important elements in the lifelong education of the engineer is the recognition by the individual that learning is self-discipline. Unless one has the desire to extend his knowledge, no amount of outside help will affect the end result."

As a learned society, your Institute stands ready at all times through Branch activities and technical meetings, through committee work and the interchange of ideas,

to assist you in what we hope will be your lifelong quest to not only continue your education so that you are a better-qualified professional engineer, better able to serve the public, but that you will also contribute to that dissemination of professional knowledge which is so helpful to your fellow engineers and to the profession.

F. L. Lawton, President.

• Library Notes *(Continued from page 84)*

TECHNIQUE DE L'EMPLOI DES RELAIS DANS LES MACHINES AUTOMATIQUES.

The aim of this text is to enable those not familiar with commutation to understand electrical diagrams. As might be expected, the book is well illustrated with many diagrams. (Claude Polgar. Paris, Eyrolles, 1961. 335p., 63.85 NF.)

*FOUNDATIONS OF STRUCTURES, 2nd ed.

This text considers the exploration of soils, reviews some of the principles of foundation action, and studies the design of isolated and combined footings, foundation walls, mats, foundations subjected to overturning, pile foundations, cofferdams, caissons, bridge piers and abutments, underpinning of structures, and machinery foundations. This edition contains additional data as well as a revision of the earlier text. (C. W. Dunham. Toronto, McGraw-Hill, 1962. 722p., $14.95.)

*MECHANICAL ESTIMATOR'S GUIDE, 2nd ed.

This manual for the air conditioning industry attempts to take cost estimating out of the realm of the personal notebook. Some thirty tables cover recommended dimensions, gages, and materials, as well as conversion factors and selection guides. (John Gladstone. Miami, Technical Guide Publications, 1961. 152p., $7.95.)

*PHOTOCHEMISTRY OF AIR POLLUTION.

By correlation and analysis of existing information this book provides a background for the study of photochemical processes which may convert relatively innocuous pollutants into substances which are nuisances and hazards. (P. A. Leighton. New York, Academic, 1961. 300p., $9.00.)

*INTRODUCTION TO HYPERSONIC FLOW.

This translation of a 1959 Soviet text provides an introduction to the fundamentals of inviscid hypersonic flow theory and to the most important methods of calculating ideal gas flows at hypersonic speeds. An extensive reference list of almost two hundred Soviet and Western publications is made particularly useful by the inclusion of references to English translations for most of the Russian works. (G. G. Chernyi. Trans. and ed. by R. F. Probstein, New York, Academic, 1961. 262p., $8.00.)

MECHANICAL HANDLING DIRECTORY.

This British directory has been produced by the periodical Mechanical Handling. The first section of the directory is a classified guide to the manufacturers of almost 400 items of equipment. Other sections include a list of proprietary names, and an alphabetical listing of companies. (London, Iliffe for Mechanical Handling, 1962. 440p., 42/-.)

(Continued on page 104)

Employment Service

THE ENGINEERING INSTITUTE OF CANADA

This service is operated for the benefit of members of the Engineering Institute of Canada and for organizations employing engineers.

SITUATIONS WANTED

Advertisements are inserted free of charge for members of all classes. Maximum length is 60 words, and repeat insertions must be separately requested in writing for each desired appearance.

SITUATIONS VACANT

Rate: Six dollars per column-half-inch per insertion.
Replies to advertisements should be addressed to the file number, Employment Service, 2050 Mansfield Street, Montreal. Interviews with the Employment Service may be arranged by calling VI 2-8121 at the above address.

SITUATIONS WANTED

ELECTRICAL ENGINEER — B.Eng. '55, P.Eng. (Que.), M.E.I.C., desires position commensurate with the following experience: 7 years diversified experience in generation, transmission and distribution with both a large public utility and a small private one. Experience includes maintenance of existing equipment plus design and construction of new or extension facilities. No location preference —presently located in Quebec. File No. 6099-E.

METALLURGICAL ENGINEERING STUDENT, S.E.I.C., age 25. Desires position with potential growth. Junior year N.S.-T.C. (minus one subject) completed. Senior year mineral dressing and ferrous metallurgy courses completed. Experience —ore research, mill maintenance, sales. Will locate anywhere, including isolated area, immediately. File No. 218-S/Met.

MECHANICAL ENGINEER, A.M.I.MECH.-E., P.Eng., age 34, married, 2 children. Experienced in development and production of electro-mechanical and mechanical units associated with electronics industry. 14 years in England, 5 years in Canada, including 3 years proven supervising experience of large drafting office. At present engaged on product design. Seeks senior position in industry offering advancement in the Montreal area. File No. 324-M.

ENGINEER, First Class Hons. B.Sc. (1947), age 35. 15 years diversified experience including gas turbines, aerodynamics, aircraft control, servos, analog computation, electronic systems, supervision of engineers. Willing to relocate. File No. 323-M.

ELECTRICAL ENGINEER, M.E.I.C., B.Sc. 1950, P.Eng., age 35, single. 4 years experience in electrical maintenance, protective relaying, testing and reports in industry; 1 year teaching, and 1 year substation design. Desires position as design or plant engineer in industry. Located Prairie Province. File No. 322-E.

CIVIL ENGINEER, A.M.E.I.C., B.Sc. (U.N.B. 1959), D.I.C. (1963), Ph.D. (1963) (Soil Mechanics, London), recipient of Athlone Fellowship and the Special Scholarship of the N.R.C. Age 26, married, no family. 6 summers experience with consulting firms (2, hydro-electric projects—4, supervision and control of materials laboratory). Seeks position with challenge and opportunity in Soil Mechanics/Foundations field. Will locate anywhere in world. Available July 1963. File No. 318-C.

MECHANICAL ENGINEER desires position in senior sales or sales management. 12 years experience in pumps, heat exchangers, power plant equipment, packaged sewage plants, budgets and estimates, industrial sales experience, administrative experience, contacting consulting engineers. Location Montreal. File No. 321-M.

CIVIL ENGINEER, M.E.I.C., P.Eng., age 40, married. Desires administrative position where Civil engineering background of benefit in management. 16 years' experience mostly in tropics; 10 years project engineer in field and office on construction and maintenance of roads, buildings, flood control, land reclamation; 6 years senior administrative experience as client's engineer and as client. Preferably Toronto area location. File No. 320-C.

GEOLOGICAL ENGINEER PETROGRAPHER, P.Eng., age under 30, Canadian. Experienced in surface geology, gravel and ground water location, decorative stones, soils, highway construction, design and subsurface rocks, exploration, testing, drilling holes, core examination, grouting. Will accept position either full or part time. Married, no children. Free to travel. File No. 319-Min.

MECHANICAL ENGINEER, M.E.I.C., P. Eng. (Ont.), age 37, married, 2 children, presently residing in Ontario, desires progressive position in the Maritimes or Province of Quebec. Supervisory and administrative experience in project coordination, inspection, design, specifications and standards. Wide practical and theoretical knowledge of plant equipment, machinery, materials of construction, etc. Past experience includes petrochemical plants and manufacturing engineering. File No. 317-M.

CIVIL ENGINEER — M.E.I.C., P.Eng. (Que.), age 43, married bilingual. 10 years' broad experience in concrete design and technology, lightweight, heavyweight concrete, prefabrication of structural and architectural units, bridges etc., seeks employment with manufacturer, consulting engineer, or architect, with eventual partnership. File No. 316-C.

CIVIL ENGINEER — B.Sc. (London), A.M.I.C.E., seeks appointment in Canada. Age 36. Four years roads and bridges, three years crane structures research, four years lecturing (materials and structures). Now with West African Building Research Institute (concrete and timber structural research, materials testing and advisory service). Desires appointment in materials testing and control, structural design, or research. Available October 1962. File No. 315-C.

MECHANICAL ENGINEER, M.E.I.C., G. I. Mech. E., B.Eng. N.S.T.C. 1954, Athlone Fellow 1954-56. Age 29, married. 3 years' experience designing nuclear experimental equipment in Canada. 3 years' supervision of equipment design and development of basic designs for nuclear power stations in England. Canadian citizen returning end of September 1962. Seeks responsible position in mechanical design or project work. Complete resume on request. File No. 294-M.

MECHANICAL ENGINEER, M.E.I.C., G.I. MECH.E. Age 33. Married, 1 child. Seeks position as Production Engineer, Manufacturing Engineer, Tool Engineer, or other supervisory position in manufacturing. 17 years diversified experience in industry, shop work, drafting, tool design, product design and development, machine design, estimating, methods, equipment selection and purchase, budgetary and cost control, supervisory and administrative experience. Preferred location, Ontario. File No. 277-M.

STRUCTURAL ENGINEER. A.M.E.I.C. Athlone Fellow, B.Sc. (U.N.B.) 1960. Diploma of Imperial College 1961 in Concrete Structures. Presently investigating the inelastic properties of reinforced concrete for M.Sc. (London). Available January 1963. Age 23, married. Willing to work anywhere in Canada. Desire position in a design company offering experience in reinforced and prestressed concrete. File No. 273-Str.

SITUATIONS VACANT

CIVIL

HIGHWAY RESEARCH — CIVIL ENGINEER, preferably with M.Sc. in Highway Engineering or Soil Mechanics, to conduct research into the physical properties of paving materials, and the design and evaluation of pavements. Current studies include the stabilization of soils and investigations into the performance and behaviour of pavements in service. The work is within the Highway Research Division, as part of the Alberta Joint Highway Research Programme. Salary—$5400-$6900 (Jr. Research Officer II) depending upon qualifications. Please submit complete resume on first reply to Industrial Engineering Services, Research Council of Alberta, 87th Avenue & 114th Street, Edmonton, Alberta.

CIVIL ENGINEER — A national association with headquarters in Ottawa requires an engineer interested in all aspects of highway research and development. Candidates should have a special aptitude for the writing of reports and technical correspondence. Salary — $5,000 to $6,000. Applications or enquiries for further information. File No. 234-V.

CHEMICAL

CHEMICAL ENGINEER — Preferably one who has had experience in operating high temperature vinyl coating ovens. Top salaries for the above positions. Excellent opportunity for advancement. Fringe benefits. Apply, with full references, to File No. 240-V.

ENGINEERING EDUCATION IN CANADA

Laval University

With a student body of 1,200 spread over 12 departments and a teaching staff of 155, of whom 98 are full time, the Faculty of Science has experienced a phenomenal development since its foundation in 1937.

It is an outgrowth of the "Ecole Supérieure de Chimie", first institution of higher learning in the field of science at Laval. Created in 1920 for the training of professional chemists, this School was to occupy for 15 years an isolated building near the Quebec City limits. A rather small student body was then in attendance; the staff of six professors understood at once the great importance of a thorough training in mathematics and in the basic sciences, rather than one limited to narrow professional requirements.

Such an approach provided a solid foundation which called for a healthy expansion, and it soon proved to be most fruitful. Indeed, through the helpful guidance and dynamic efforts of Mr. A. Pouliot, an engineer among the original six professors and Dean of the Faculty from 1939 until 1956, the scope of the first School was considerably expanded by the addition, in 1937, of the "Ecole des Mines, de la Géologie et de la Métallurgie". Thus came into being the Faculty of Science which was to provide for the training of engineering students at Laval. By that time the student body had reached 37, more than half of them in first year engineering. The number of professors was up to 12 full-time and six part-time.

As the rate of development started growing and gathering speed, a second building was added, mostly for engineering students. One department after another was formed, taking into account such divergent factors as the financial means available and the ever growing number of students leaving after their second year to complete elsewhere their studies in branches of engineering not yet available at Laval.

After the original engineering departments of mining and metallurgy, dating back to 1937, the others came into being as follows:

Chemical Engineering	—	1940
Electrical Engineering	—	1942
Geological Engineering*	—	1945
Civil Engineering	—	1950
Mechanical Engineering	—	1954
Engineering physics*	—	1957

(* Not as a separate department.)

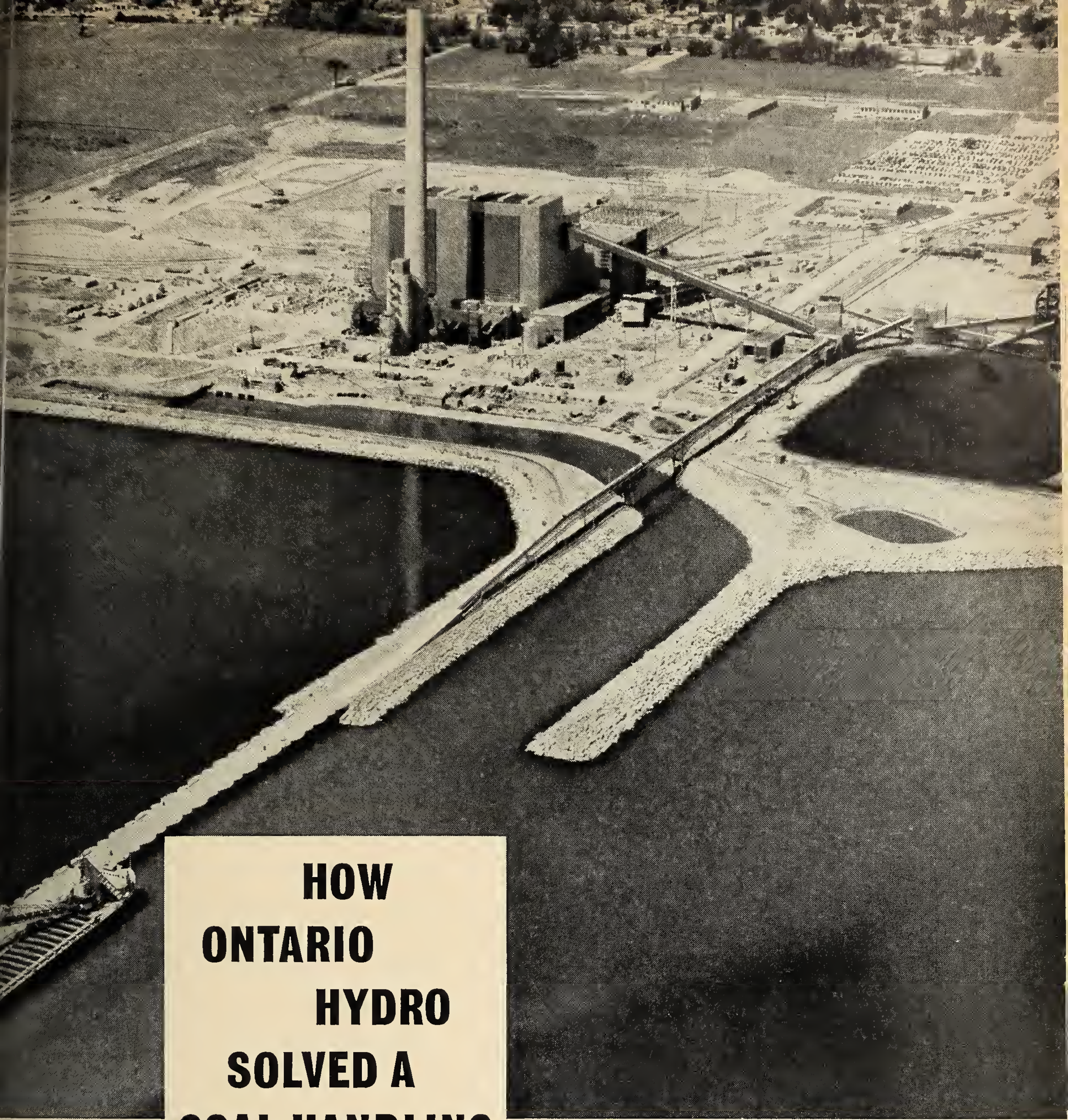
At one point in this period of development, in 1945-46, the Silver Jubilee of "Ecole Supérieure de Chimie" was the occasion for a thorough, University-wide stock-taking. The staff of the Faculty had then increased to 73, of whom 30 were part time, and the student body of 370 occupied space which had been planned for only three hundred. The future needs of the Faculty were not only apparent but they were looming as an obvious problem and burden for the University, considering the extensive developments it had to face in other Faculties as well.

Looking boldly at the future it was realized that the only logical solution was to move progressively the whole University to a completely new campus, over a mile square, beyond the city limits. Once the decision to implement such a move was taken, it meant that all future expansion was to take place on the new campus, barring any measures which would have been taken normally to expand on the site of already existing buildings. Yet, developments at the Faculty in the following years kept taking place and new departments were added, with the result that all facilities were strained to a point such that the basic minimum requirements were threatened unless urgent measures were taken.

Some relief was obtained by moving students in first and second year to temporary quarters on the new campus for their lectures. Still, overcrowding presented more and more of a problem as the number of students in the last three years kept increasing and requirements for research activities were expanding. In this field alone there are at present 59 graduate students in engineering, 46 of them working toward a Master's degree and 13 toward a Doctor's.

A solution to the problem came in a long hoped-for announcement made almost three years ago. The Faculty of Science was to be provided with two large buildings designed to accommodate over 2,000 students. They have been a-building for over two years now and are nearing completion. The accompanying Figure illustrates the general view that will be presented by the two buildings. The engineering building, on the right, exhibits individual wings for mechanical, chemical, mining and metallurgy, and civil engineering. Electrical engineering is located in that part of the main

(Continued on page 98)



HOW ONTARIO HYDRO SOLVED A COAL HANDLING PROBLEM

Bird's-eye view of coal-handling system at the Lakeview Thermal-Electric Generating Station, of Ontario Hydro in Toronto Township.

To maintain adequate power output the year 'round
d hold costs in line was the dual problem in designing one of the world's largest thermal-
ectric generating stations. Coal must be delivered and stockpiled during the navigation
ason. Hydro engineers solved the coal handling problem with a conveyor system*. □ Goodyear
proud to have worked with Hydro personnel from project planning thru' to actual operation,
d to have designed and supplied the conveyor belting for this system. □ Goodyear Technical
rvice is always ready to match industries' needs with rubber products engineered to provide
icient operation at lowest possible cost. For information contact your nearest Goodyear
anch or Head Sales Office, Bowmanville, Ontario.

TO BE SURE CALL **GOODYEAR**

INDUSTRIAL RUBBER PRODUCTS ENGINEERED FOR YOUR JOB

ipment installed by Stephens-Adamson Mfg. Company Limited

(Continued from page 96)

1951 Re-arranged and revised curricula with larger core of humanities and social studies in all Engineering departments.

1955 Resignation of Professor N. A. Williams and promotion of Professor J. P. C. McMath to Head of Electrical Engineering.

1956 Retirement of Professor N. M. Hall and promotion of Professor R. E. Chant to Head of Mechanical Engineering. Professor Hall named Professor Emeritus.

1957 Formal opening of Fetherstonhaugh High Voltage Laboratory (about 3,000 square feet gross) by Dean Emeritus E. P. Fetherstonhaugh — on occasion of Golden Jubilee of Engineering instruction at The University of Manitoba.

1958 Further two-storey (about 14,500 square feet gross) addition to south-wing extension and one-storey (about 7,250 square feet gross) middle-wing westerly extension to Engineering Building.

1959 Death of Dean Emeritus E. P. Fetherstonhaugh — October 19, 1959 — Dean from 1921-49.

1961 Further two-storey (about 14,500 square feet gross) addition to middle-wing extension of Engineering Building planned to go ahead summer of 1962.

1962 Scale model of proposed Red River floodway built and under study.

The plan view of the Engineering Building is now that of a capital E, with the long side facing easterly. Sketch plans are under way for a three-storey and basement L-shaped extension of the north-wing westerly, and then southerly to line up with the Fetherstonhaugh High Voltage Laboratory.

University of Waterloo

History is so recent at the University of Waterloo that one should perhaps speak of "current events" in reference to the Co-operative Engineering Course established in 1957. The basic concept on which the program is founded can be stated quite simply: the preparation for an engineering career should include both formal academic studies at a university and intensive training in the practice of engineering during the undergraduate years. Thus the program, as it is now developed, includes eight four-month academic terms alternating with six four-month field assignments with co-operating companies. Two of the academic terms, either the first two or last two, are adjacent and hence each student spends one "conventional year" of September to April on the campus. The original "quarter system" of four three-month terms has been modified to three four-month terms to achieve integration with the normal terms of the other Faculties which have since been established.

The success of the Waterloo program, which is unique in Canada, depends in a large measure on the splendid co-operation received from more than 270 co-operating companies that have helped to shape our student's professional lives. A Department of Co-ordination has functioned from the beginning to arrange for and guide our students in all field assignments. A. S. Barber, Director of Co-ordination and Placement, along with his staff of experienced co-ordinators has established a wide liaison with the "off-campus faculty" — Canadian industry.

The University of Waterloo is unique in another respect — the Faculties of Science, Arts, and Graduate Studies were formed after the Faculty of Engineering, and our first convocation included graduate degrees in Engineering.

The first graduating class of students on the co-operative course emerged in July, 1962 — having survived the ordeals of a rapidly developing new institution. More than 800 undergraduates in Engineering saw the first of their number graduate. More than a quarter of the graduating class of 72 expect to attend graduate schools in Canada and the U.S.A. and one of the graduates in Civil Engineering has been awarded an Athlone Fellowship for further study in England.

The teaching buildings at Waterloo now comprise a 55,000 square foot Chemistry-Chemical Engineering Building, a 110,000 square foot Mathematics and Physics Building and a 133,000 square foot Engineering Building which was completed in the Fall of 1961. An Arts Building is under construction and a Library and Chemistry-Biology Building are being planned.

The co-operative experiment at the University of Waterloo has been a success and we feel well poised for further significant contributions to Canadian Engineering education.

Library Notes

(Continued from page 91)

THE ECONOMICS OF UNEMPLOYMENT COMPENSATION.

Although confined to the scene in the United States, this study will be of interest to readers in Canada where many of the problems are the same. The topics covered in the study are the economic significance of unemployment benefits, and their adequacy; the effect of changes in the labour force; methods of financing unemployment payments; barriers to revision of the programme; proposals for its reform and improvement. (R. A. Lester. Princeton, University, Industrial Relations Section, 1962. 137p., $3.75.)

HEALTH IN INDUSTRY.

This "guide for engineers, executives, and doctors" covers: the health of the executive; absence from work due to sickness; design of equipment from the human point of view; human aspects of industrial accidents; industrial fatigue; the effect of surroundings on work; the effect of chemicals. (R. C. Browne. Toronto, Macmillan, 1961. 157p., $3.25.)

*AUTOMATIC AND REMOTE CONTROL: PROCEEDINGS OF THE FIRST INTERNATIONAL CONGRESS OF THE INTERNATIONAL INTERNATIONAL
FEDERATION OF AUTOMATIC CONTROL, Moscow, 1960.

Some 300 papers are contained in the English edition of this important congress. Volume 1 covers the theoretical aspects of continuous linear and non-linear systems, discrete system, and optinal systems; Volume II continues with theory for self-adjusting systems, then deals with statistical methods of investigation, theory of structure and signal composition, simulation and experimental methods, and with mathematical problems and terminology; Volume III covers components, including computers, remote and supervisory control devices, pneumatic components and automatic control instrumentation. The eight sections of Volume IV present applications of automation in metalworking, electrical power systems, electrical drives and machines, transport, industrial processes, chemical and petroleum industries, thermal and nuclear power, and metallurgical processes. Volume III only is in the E.I.C. library. (Toronto, Butterworth, 1961. 4 vols., $165.00 for set of 4, $44.00 per vol.)

DIGEST OF LITERATURE ON DIELECTRICS, VOL. 24, 1960.

Prepared by a committee of the Conference on Electrical Insulation this volume comprises a series of articles reviewing the literature on dielectrics. Altogether, reference is made to nearly 1700 articles, most of which appeared during 1960. The nine chapters were compiled by experts in the field, and cover: instrumentation and measurement; tables of dielectric constants; molecular and ionic interactions in dielectrics; electrical conduction; the breakdown of dielectrics; ferroelectric and piezoelectric materials; high polymeric materials; insulating films and fibrous materials; solid organic insulation, applications. (Ed. by T. D. Callinan and A. M. Parks. Washington, National Academy of Sciences-N.R.C., 1961. 303p., mimeog., $8.00 publ. 917.)

*1961 BOOK OF A.S.T.M. STANDARDS.

This is the triennial publication of ASTM Standards, and contains 17,000 pages with 3,000 standard specifications, testing methods, definitions, and recommended practices. Plastics and carbon black are now in a separate volume from Rubber and electrical insulation standards. Metals specifications and testing methods, non-metallic materials, petroleum products, industrial chemicals, and textiles comprise the remaining volumes. (Philadelphia, The American Society for Testing and Materials, 1961. 11 volumes, $195.00 for the set.) Individual volumes may also be purchased.

(Continued on page 108)

Library Notes

(Continued from page 104)

CHANNEL UNDERGROUND.

The first proposal for a tunnel under the English Channel was put forward in 1802, now, the subject is being investigated once more. The author follows an historical survey with a discussion of the geological and engineering problems involved, the economics of tunnel traffic, financing construction and tunnel law. (Deryek Abel. London, Pall Mall, 1961. 127p., 17/6.)

COMPUTER BASICS.

Developed for a course intended to train U.S. Navy electronics technicians to operate and service computers, these five volumes present the subject in a logical manner. (Technical Education and Management Inc., Indianapolis, Sams, 1961. 5 vols., $22.50.)

PUBLIC CLEANSING: PRESENT AND FUTURE.

The well-qualified author of this account of garbage collection and disposal provides a review of the various techniques available for the storage of domestic dry waste, the collection of garbage, and the disposal of waste. (A. G. Davies. London, Spon, 1961. 195p., £2.)

SHOCK TUBES.

The shock tube is a development of the last 15 years, and the purpose of this monograph is to give an account of the theory of shock waves, the principles of operation of shock tubes, and the more important investigations using shock tubes. Useful bibliographies are included. (J. K. Wright, London, Methuen, 1961. 164p., 15/-.)

AN ELEMENTARY TREATISE ON THE MECHANICS OF FLUIDS.

Intended primarily as an undergraduate text, the aim of this book is to provide a systematic and easily understood account of the basic principles of the science of the mechanics of fluids, and to cover some of the elementary technical applieations. (W. J. Duncan and others. Toronto, MacMillan, 1960. 714p., $12.60.)

THE AMERICAN CENTURY OF JOHN C. LINCOLN.

In the century since the Civil War, the United States has made great material gains. Much of this expansion has been due to the efforts of a few men, one of whom was John C. Lincoln who was born in 1866 and died in 1959. His major contributions were in the field of electrical engineering. (Raymond Morley. Toronto, General Publishing, 1962. 209p., $5.95.)

*PERMANENT MAGNETS AND THEIR APPLICATION.

Presenting the basic principles, concepts, and practices of the field, this book provides a basis for predicting magnet performance. Treated in detail are the problems of magnetization, demagnetization stability, and measurements. (R. J. Parker and R. J. Studders. New York, Wiley, 1962. 406p., $16.00.)

*SEMICONDUCTOR RELIABILITY.

The papers included in this volume were presented at the Conference on Reliability of Semiconductor Devices, 1961, sponsored by the Working Group on Semieonductor Devices, Advisory Group on Electron Tubes, Department of Defense. They provide a comprehensive body of information on the status of semiconductor device reliability. (J. E. Schwop and H. J. Sullivan. New York, Reinhold, 1961. 309p., $8.50.)

PRODUCTION MANAGEMENT.

This text deals with production management principles and practice for manufacturing companies. It does not include office management, personnel administration or budgeting. Many practical examples are included, as are charts, graphs and photographs. (H. N. Broom. Homewood, Ill., Irwin, 1962. 768p., $10.60.)

(Continued on page 116)

• Library Notes

(Continued from page 108)

TABLES FOR THE COMPRESSIBLE FLOW OF DRY AIR.

These tables for the parameters of isentropic, Prandtl-Meyer expansive, Rayleigh, Fanno, plane normal and plane oblique shock flows are intended both for students and practising engineers. The tables themselves are preceded by a brief introductory text. (E. L. Houghton and A. E. Brock. Toronto, Macmillan, 1961. 64p., $2.25.)

RADIO AMATEUR'S HANDBOOK, 39TH ED., 1962.

In this edition, the chapters on the theory of radiocommunications have been brought up-to-date, as have those on equipment construction, vacuum-tube characteristics, and tube-base diagrams. A catalogue section is included. (West Hartford, American Radio Relay League, 1962. 590p., $4.00.)

ANTI-CORROSION MANUAL, 4TH ED.

Revised to include developments which have occurred since the publication of the third edition, this edition contains a new chapter on corrosion engineering problems in various locations, water storage tanks, structures in sea water, jetties, and steel chimney stacks. A directory and buyers' guide is included. (London, Corrosion Prevention and Control, 1962. 454p.)

MANUEL D'ANTICORROSION: *T.* 2 APPLICATIONS DES TECHNIQUES D'ANTICORROSION.

The first volume of this two volume work dealt with the theory of corrosion, and problems of a general nature. This second volume is concerned with causes of corrosion in specific locations, and methods of combatting it. (A. J. Maurin. Paris, Eyrolles, 1962. 320p., 44.70 NF.)

AN INTRODUCTION TO INFRARED SPECTROSCOPY.

The purpose of this book is not to provide an exhaustive treatise on infrared spectroscopy but to help scientists overcome difficulties connected with starting in a new field. The experimental side of the subject is emphasized. (Werner Brugel. London, Methuen, 1962. 419p., 55/-.)

*AN INTRODUCTION TO MAGNETO-FLUID MECHANICS.

This introductory account of magneto-fluid dynamics includes the interaction of a highly conducting fluid with a magnetic field, the kinetic theory of a highly ionized gas, and discussions of transport coefficients, the conduction of electricity in a plasma in the presence of a magnetic field, and plasma oscillations. (V. C. A. Ferraro and C. Plumpton. Toronto, Oxford, 1961. 181p., $3.75.)

MOTION AND TIME STUDY, 3RD ED.

This third edition includes new material on waiting line theory; the technique of Monte Carlo methods; quantitative techniques applied to man and machine relationships; and the position of unions in relation to time and motion study. (B. W. Niebel. Homewood, Ill., Irwin, 1962. 568p., $10.65.)

MUNICIPAL COMPOSTING.

A companion volume to the author's Public Cleansing, this book discusses the treatment of waste matter to form compost. Described are the various methods of composting and types of plant in use throughout the world. A bibliography is included. (A. G. Davies. Toronto, British Book Service, 1961. 203p., $7.25.)

BIBLIOGRAPHY OF LOW TEMPERATURE ENGINEERING AND RESEARCH, 1944-1960.

The periodical Cryogenics, of which this is a supplement, first appeared in 1960, and includes lists of current literature. This bibliography covers the years from 1944 to that date. References to more than 5,000 articles, taken from 186 periodicals, are included. (Ed. by K. Mendelssohn and others. London, Heywood, 1961. 160p., 25/-.)

(Continued on page 118)

Library Notes

(Continued from page 116)

***ADHESION.**

This is an edited presentation based on information gained by the Adhesion Panel of the Advisory Council on Scientific Research and Technical Development of the Ministry of Supply of Great Britain, established in 1949. The general approach throughout most of the book is through consideration of the separate aspects of wetting and stress concentration. (Ed. by D. D. Eley. Toronto, Oxford, 1961. 290p., $8.25.)

ELECTROTECHNOLOGY.

Intended for undergraduate students, the aim of this series is to provide a set of low priced books, each covering one aspect of the subject. The author is head of the Electrical and Radio Schools of the International Correspondence Schools. (D. L. Carr. Toronto, Macmillan, 1962. 6 vols., 90 cents ea.)

***PROPERTIES OF SOLIDS.**

By characterizing the properties of materials in such a way that they can be represented as tensors of various ranks it is possible to bring the phenomenological treatment of all material properties into the operational framework of tensor algebra. (G. G. Koerber. Englewood Cliffs, Prentice-Hall, 1962. 286p., $13.00.)

INTERNATIONAL SYMPOSIUM ON MAXIMUM ALLOWABLE CONCENTRATIONS OF TOXIC SUBSTANCES IN INDUSTRY. PROCEEDINGS.

The volume contains many of the papers presented at the first international symposium on this subject, held in Prague in 1959, and abstracts of others. Participants at the symposium came from all over Europe, as well as Canada and the U.S.A. The papers are published in English, French or German, and are divided into four sections. (Toronto, Butterworth, 1961. 373p., $10.50.)

BRITISH TRANSISTOR DIODE AND SEMICONDUCTOR DEVICES DATA ANNUAL, 1962-63.

A companion volume to the "British miniature electronic components and assemblies data annual" this volume covers transistors, diodes, and semiconductor devices made in the United Kingdom. There are more than 900 pages of data sheets for the transistors, diodes, and semiconductors available, giving very detailed information for each. (Ed. by G. W. A. Durnmer and J. M. Robertson. London, Pergamon, 1962. 935p., $25.00.)

CHIMIE PHYSIQUE DES SEMICONDUCTEURS.

Developed from a conference held in Bordeaux in 1957, this text will be of interest to chemists, as it considers semiconduetability in relation to crystalline structure, and its role in interatomic liaisons. It discusses mechanisms of semiconductability, interactions between faults, semiconductor materials. (J. P. Suchet. Paris, Dunod, 1961. 221p., 19NF.)

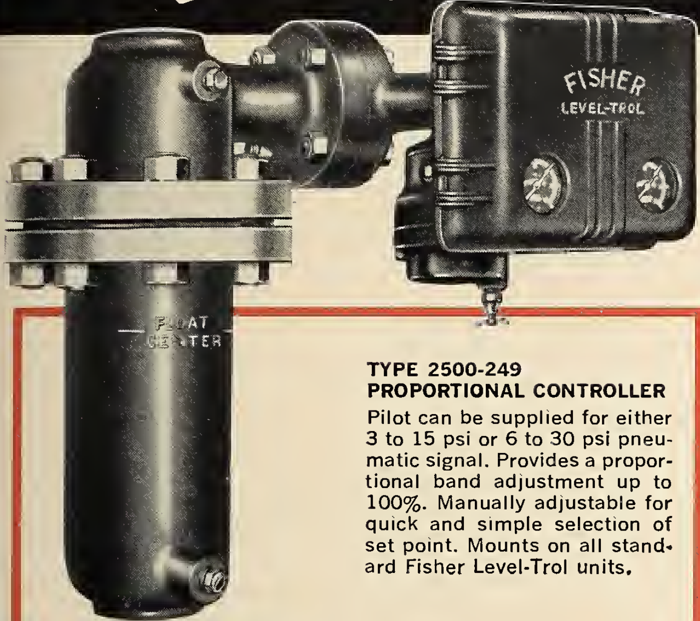
***AUTOMATIC AND FLUID TRANSMISSIONS.**

A comprehensive British study of automatic transmissions, covering both principles and practical aspects of design, installation, and operation. Mechanical, electrical and hydraulic systems are dealt with, together with semi-automatic devices and overdrives. Most of the proprietary American, British, and continental transmissions are reviewed in some detail, and mention is made of some devices still under development. (J. G. Giles. Toronto, Nelson Foster and Scott, 1961. 328p., $11.25.)

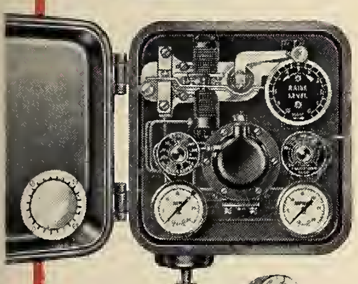
***THEORIE UND BERECHNUNG DER ROTATIONSSCHALEN.**

A volume on the theory and analysis of shells of revolution. Beginning with theoretical fundamentals, the reader is gradually introduced to the general methods and analysis for shells with geometrically fixed center surfaces. Shells of revolution are then dealt with by both exact and approximation methods. In this connection the asymptotic methods, applied to shells with constant or variable curvatures and thicknesses are fully discussed. There is a bibliography. (P. B. J. Gravina. Berlin, Springer-Verlag, 1961. 308p., 43.50 DM.)

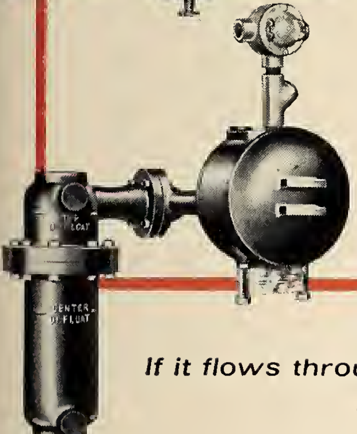
(Continued on page 120)



TYPE 2500-249 PROPORTIONAL CONTROLLER
Pilot can be supplied for either 3 to 15 psi or 6 to 30 psi pneumatic signal. Provides a proportional band adjustment up to 100%. Manually adjustable for quick and simple selection of set point. Mounts on all standard Fisher Level-Trol units.



TYPE 2502 PROPORTIONAL RESET CONTROLLER
Has all the features of the Type 2500 plus reset action. Brings the set point back automatically to its original position and assures absolutely stable control. Proportional band adjustable to 200%; reset rate adjustable from .005 to 1 minute per repeat.



TYPE 2310 ELECTRONIC CONTROLLER
Explosion-proof design. External adjustment for proportional band (10 to 100%) and liquid level set point. Delivers either a proportional 1 to 5, 10 to 50, or 4 to 20 milliampere dc signal. Has plug-in converter with printed circuit. Mounts on standard Level-Trol housings.

Versatile...

Will handle practically any liquid level, interface level or specific gravity control or indication problem.

Pneumatic or electronic pilots...

Level-Trols can operate either type pilot using essentially the same float assembly and other components.

Displacement floats—14" through 120" lengths...

Available with cage units for external mounting or internal top or side flange mounting.

Fisher Level-Trols operate on a simple displacement principle. A cylindrical shaped displacer float and a torque tube spring provide a mechanical motion virtually free of friction that transmits level changes to the pilot. It is an extremely accurate means of continuously measuring liquid level or specific gravity. Three basic controllers are shown at left; for more detailed information on Level-Trols write FISHER GOVERNOR COMPANY OF CANADA, LTD., Woodstock, Ont. —ask for Bulletins F-4B and F-85A.

If it flows through pipe anywhere in the world ...chances are it's controlled by...

FISHER® Controls
SINCE 1880

Library Notes

(Continued from page 118)

MATRICES FOR STRUCTURAL ANALYSIS.

Civil engineers are increasingly making use of methods of analysis which require the use of matrix methods. This text is concerned with the application of matrices to structural problems, concentrating primarily on actual calculations, although theory is also given. Specific problems in structural analysis are dealt with, and it is shown how the different numbers are calculated from the data, and assembled into matrices. Calculations of the final result are also given in detail. Special emphasis is placed on the elementary steps which form a basis for later work. (S. J. McMinn. London, Spon, 1962. 210p., 57/6.)

GREAT ENGINEERS.

The story of the Industrial Revolution in England, told through the lives of ten men, the first of whom, Abraham Darby, was born in 1678, and the last Frederick Lanchester, died in 1946. That period of less than three centuries started with Darby's discovery of the art of coke smelting, and closed with Lanchester's contributions to automobile engineering and aviation. The other eight biographies cover the period in between: Newcomen and mechanical power; Jessop the builder of canals and railways; Murray, improved steam engines; Maudslay, the master mechanic; Locke, the railway engineer; Fowler, the first to till the soil by mechanical power; Baker, the designer of the Forth Bridge, Crompton with his dynamos and improved roads. They all made their contribution to the modern world. (L. T. C. Rolt. Toronto, Clarke, Irwin, 1962. 244p., $4.00.)

°SEISMIC EFFECTS OF UNDERGROUND EXPLOSIONS.

Four papers are included in this translation of a Russian work. The first furnishes information on seismic observations in the U.S.S.R. and in other countries and analyses this information from the viewpoint of possible detection and recognition of underground nuclear explosions. The second discusses the results of determining magnitudes of nuclear explosions set off at the test site in Nevada in 1957-58. The third describes differences in the spectra of surface waves from earthquakes. The concluding paper provides a theoretical model of an explosion at an interface. Transactions (Trudy) of the O. Yu. Shmidt Institute of Geophysics, Number 15 (182). (New York Consultants Bureau, 1962. 88p., $22.50.)

A GUIDE TO OPERATIONAL RESEARCH.

The author's intention in writing this book was to give those in management a brief account of the philosophy and techniques of Operational Research, without going into detailed mathematical explanations. He defines O.R., and describes its techniques, including queueing theory, Monte Carlo method, game theory, operational gaming, etc. Finally, the author discusses the place of O.R. in an organization, how to set up a programme, and the uses of O.R. in industry. For those wishing to read more of the theory, bibliographies are included. (W. E. Duckworth, London, Methuen, 1962. 145p.)

°COAL, ITS FORMATION AND COMPOSITION, 2ND ED.

This second, enlarged edition reviews the literature that have appeared since the first edition (1954). Major changes have been made in those sections which treat terminology, classification, and petrology. Minor additions include short summaries of the nature and life cycles of bacteria and fungi, with the effects of environmental conditions, such as moisture, redox potential, and hydrogen ion concentration, on the decomposition of plant debris by those agencies. Topics treated somewhat the same as in the first edition include the origin of coal, structure of coal forming plants, chemistry of plant products, composition of peat, lignitous coal and mature coals, normal and abnormal coal forming processes, inorganic constituents of coal, and physical considerations, such as surface area and immersion swelling. From 35 to 165 references appear at the end of each chapter. (Wilfrid Francis. Toronto, MacMillan, 1961. 806p., $26.50.)

°THEORY OF TRAFFIC FLOW.

The papers in this volume treat aspects of traffic flow theory ranging from the control of traffic by means of special signal systems to the analysis of traffic flow using statistical theories and models. Other subjects covered are the design of communication and transportation networks, single lane traffic theory and experiment, distribution of traffic on a road system, and the traffic flow in single-line flow in tunnels. (Robert Herman. Amsterdam, Elsevier, 1961. 238p., 32 D.fl.)

°THERMODYNAMICS OF SOLIDS.

A general treatment of the thermodynamics of the various properties to solids. The author attempts to weave the atomistic and thermodynamic interpretation together, showing how thermodynamic measurements can be used to obtain information about the mechanisms involved. He covers all important classes of crystals and solids including metals, semi-conductors, and insulators. A major part of the book is concerned with the thermodynamics of the various defects incolved in crystalline solids. The major aim throughout is to give a working knowledge of the important phenomena involving crystalline solids. (R. A. Swalin. New York, Wiley, 1962. 343p., $12.50.)

EIC

an *electrifying* example of CO-OPERATIVE ENGINEERING

Project:

to find a man to test a rubber glove to 5,000 volts!

A manufacturer of safety equipment walked into our labs and said, "Look—I want to know if this glove is any good . . . Can you test it?"

We could and we did. But not with a man's hand, for a mere 600 volts is enough to kill our best.

We filled the glove with water and wired it 'as if'. The glove was good.

At Canada Wire we are happy to test all kinds of things for all kinds of people, including our competitors.

We have the facilities—our electrical testing labs are the largest in Canada. They have to be large for testing every foot of the thousands of miles of wire and cable we make every year, and for the research and development of new types of cables, accessories and insulating materials.

So, for inventive help *and* tested products, call on Canada Wire.

CANADA WIRE

CANADA WIRE AND CABLE COMPANY LIMITED

Postal Station R, Toronto 17 (Leaside), Ontario

INDEX TO ADVERTISERS

SEPTEMBER 1962

PUBLICATION OFFICES: The Engineering Institute of Canada, 2050 Mansfield Street, Montreal 2, Quebec, Canada.

Association of Consulting Engineers of Canada Incorporated

The following firms have principals who are members of this Association engaged as professional engineers in engineering work independent of salaried employment or sales promotion.

The revenue derived from the sale of advertising space assists the Institute in publishing THE ENGINEERING JOURNAL on a regular monthly basis. Listed above are the names of the Companies and individuals whose advertisements appear in this issue.

ADVERTISING OFFICES

QUEBEC: J. E. Donavan, Manager, Advertising Sales. Representative—Charles R. Amey, 2050 Mansfield Street, Montreal, Phone: VIctor 2-8121
ONTARIO: W. Marrison Day, 160 Eglintan Ave. E., Suite 103, Toronto, Phone: 485-0789
WESTERN CANADA: W. George Turner, 501 - 191 Lombard Ave., Winnipeg, Man., WH 3-9123
UNITED KINGDOM: H. A. Mackenzie, 4A Bloomsbury Square, London, W.C.1, England. Phone: HOlborn 3779
EUROPE: Gustav Elm, 41 Avenue Montaigne, Paris 8, France. Georg Linder, Wittelsbacher Allee 60, Frankfurt Am Main, West Germany.
NEW ENGLAND STATES: R. G. Melendy, 17 Maugus Avenue, Wellesley Hills 81, Mass. Phone: CEdar 5-6503
CHICAGO: W. Reynald Ratz, 549 W. Randalph St., Chicago 4, Ill. Phone: ST-2-8811
NEW YORK: Jahn H. Bayd, 17 East 45th Street, New York, Phone: MUrray Hill 7-0654
CALIFORNIA: Dunkle/Lehman Campany, 740 South Western Ave., Los Angeles, Calif. Phone: DUnkirk 7-6149

President
F. L. LAWTON, M.E.I.C.
Treasurer
A. W. HOWARD, M.E.I.C.
General Secretary
GARNET T. PAGE, M.E.I.C.

EIC

THE
ENGINEERING JOURNAL

VOLUME 45 NUMBER 10 OCTOBER 1962

PUBLISHED MONTHLY BY THE ENGINEERING INSTITUTE OF CANADA, 2050 MANSFIELD ST., MONTREAL 2, QUE., CANADA • TEL. VI. 2-8121

Printed in Toronto

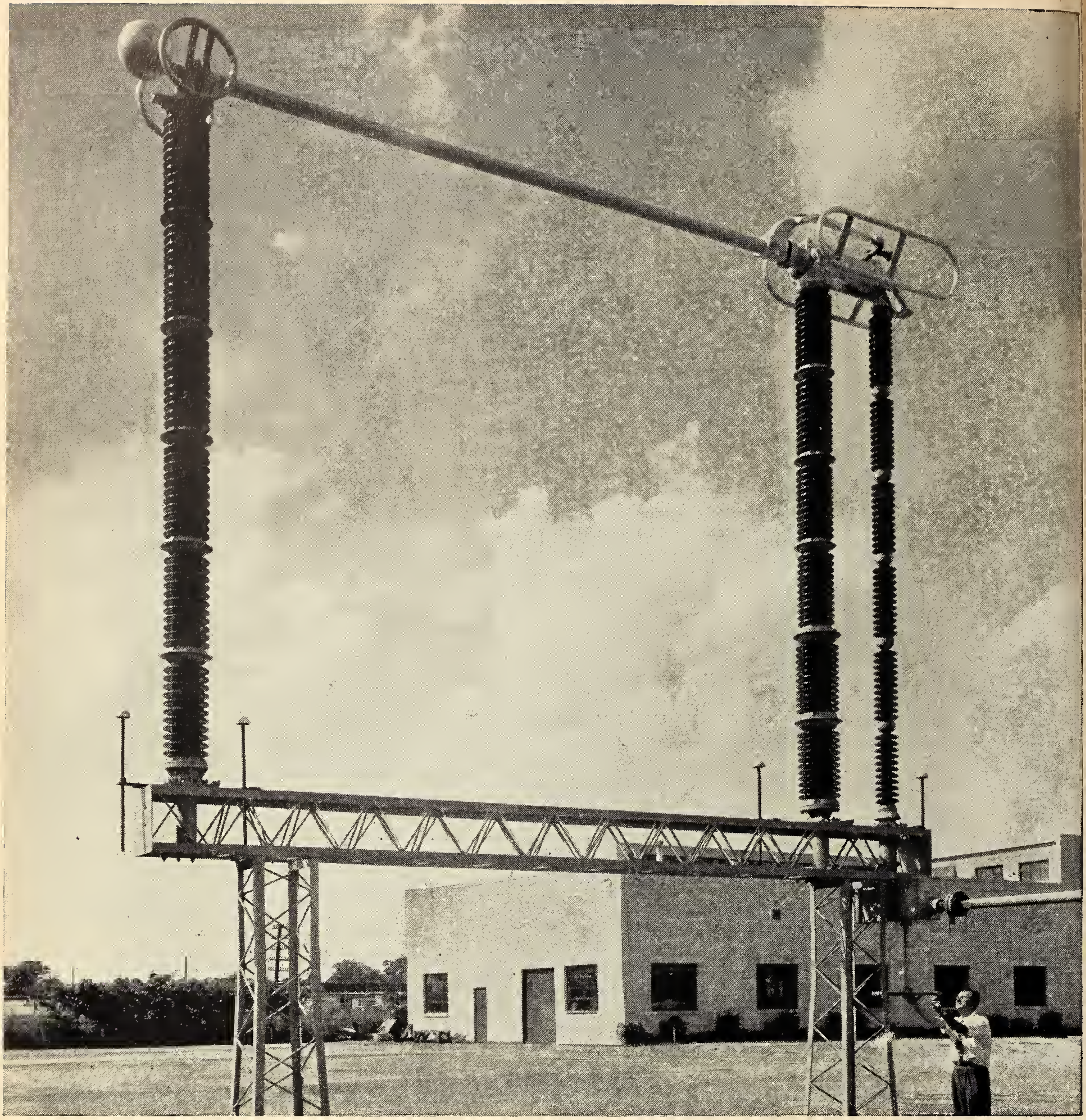
Price $6.00 a year in Canada, British Possessions, United States and Mexico. $7.50 a year in Foreign Countries. Current issues, 75 cents a copy, back issues from $1.00 per copy up. To members, affiliates and other bona fide engineers in Canada—no charge. Authorized as second class mail, by the Post Office Department, Ottawa, and for payment of postage in cash.

MEMBERSHIP

CCAB BNA

Indexed in
The Engineering Index
The Applied Science and Technology Index

CONTENTS



IN THIS ISSUE

At the Beaumont Hydro-Electric Development on the St. Maurice River, Quebec, an extensive tailrace excavation carried out by a large walking dragline resulted in a gain of head of more than 17 feet. In his paper, ***"Tailrace Improvements at the Beaumont Hydro-Electric Development"***, C. G. Smallridge, M.E.I.C., Hydraulic Engineer with The Shawinigan Engineering Company Limited, Montreal, describes the hydraulic design studies, model tests and execution of the field work with particular comments on the problems associated with the two river crossings.

G. E. Gunter, M.E.I.C., Mechanical Engineer, Design and Construction Division, New Brunswick Electric Power Commission, in his paper, ***"Design and Construction Aspects of the Beechwood Third Unit"***, describes the third and final unit as the Beechwood Generating Station on the Saint John River. The Unit, rated at 55,500 H.P. at a net head of 57 feet is somewhat larger than the existing two units. The governor for the turbine is of the electro-hydraulic type similar to those on units one and two. Investigations showed that efficiencies from the combination of the turbine and the existing draft tube were caused by an incompatibility between turbine and draft tube which manifested itself as a separation at the elbow of the tube.

R. C. McMordie, M.E.I.C., Manager, Engineering and Operations, B.C. Power Commission, in his paper ***"Some Aspects of the International Background of Columbia River Projects in Canada"***, opens with a brief description of the Columbia River, the fourth largest river in North America. To obtain a perspective of the river's power, the total power potential of the river is shown in relation to other important power rivers, for example, the St. Lawrence. The history begins with the reference in 1944 to the International Joint Commission of the problem of determining whether a greater use than was being made of the waters of the Columbia River System would be feasible and advantageous to the United States and Canada. The author describes the establishment of the International Columbia River Engineering Board, giving a resume of the Board's report of March 1959.

J. S. MacKelvie, Electronics & Electrical Engineer, H. Hollitscher, Laboratory Engineer and E. C. Elgar, Mechanical Engineer, all with Canadian General Electric Co., in Peterborough, Ont., in their paper, ***"Loss Measurement in Magnetic Steel Above Saturation Density with Controlled Flux Waveform"***, describe a means of producing controlled flux waveforms in standard steel samples over a range of method of measurement of loss is used successfully to avoid the difficulties associated with the electrical measurement of loss at saturation flux density. Measurement of peak flux density is made with an average reading voltmeter attached to a search coil which is compensated for air leakage flux. Peak magnetic field strength is measured with another search coil.

The distribution of electric power has grown rapidly since Edison started his system in 1882. Latterly the progress of this branch of engineering has been increasingly rapid with our industrial expansion. In has paper, ***"Progress in Power Distribution"***, R. E. Jones, Contributing Editor, Electrical News and Engineering, Bolton, Ont., traces distribution from the start with direct current, to the transformer and alternating current, followed by details of the evolution of the component parts of a system over the years. He reviews present practices and in conclusion makes some predictions for the future.

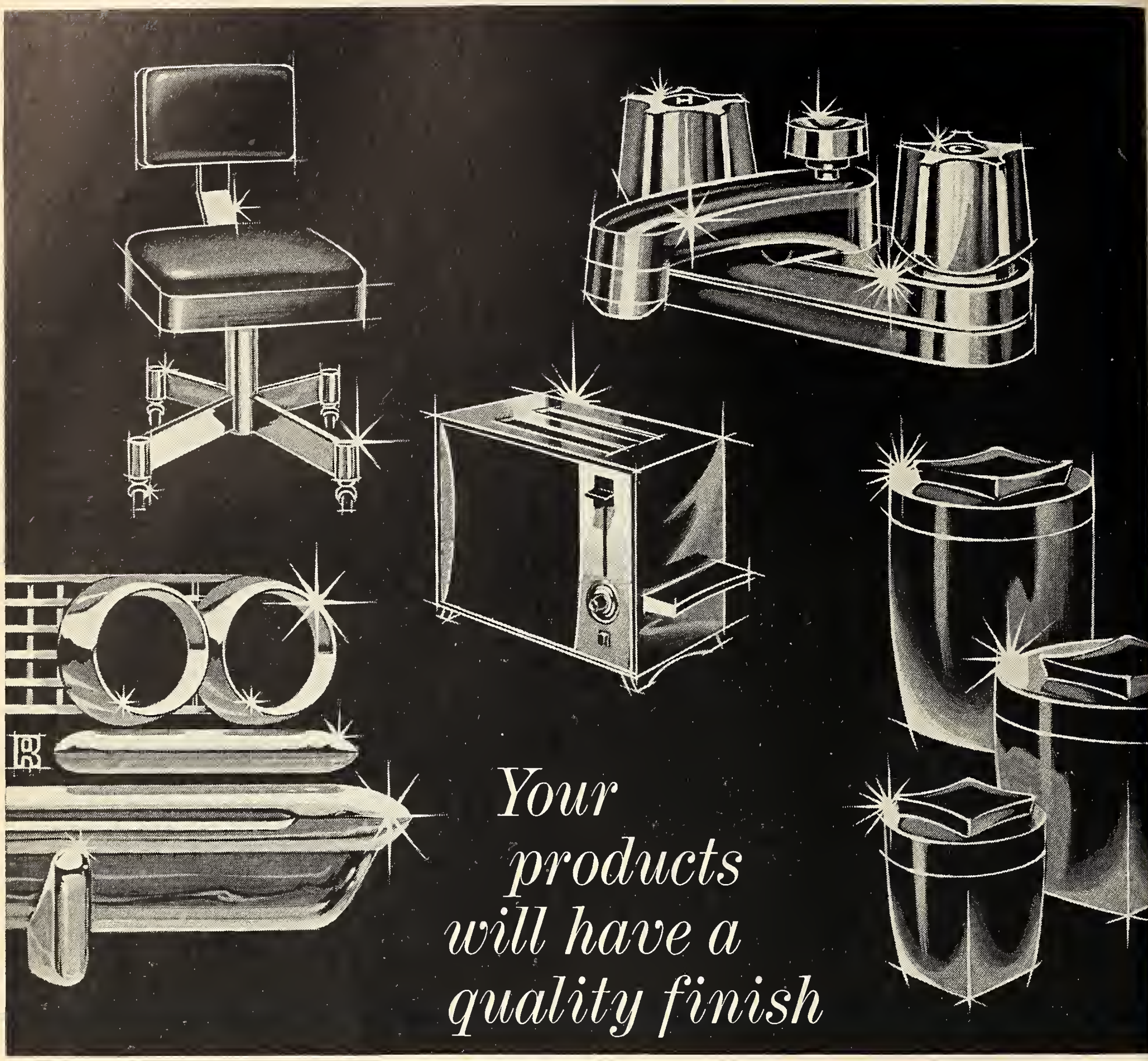
The search for power and storage in Alberta has resulted in an arrangement between the Province of Alberta and Calgary Power Ltd. to build the Brazeau Storage Development. K. G. Brittain, M.E.I.C., Design Engineer with Montreal Engineering Company, and J. L. Reid, M.E.I.C., Supervisor, at Hydro-Electric Development, Department Water Resources, Edmonton, in their paper, ***"Design Concepts of Brazeau Development Including River and Hydrology Studies"***, describe the background and events leading up to this combined effort between government and public utility.

The project, developed to produce peak capacity and peak energy, will complement other sources of power in the Province, and provisions have been made to permit its future integration with other prospective sites on the Brazeau River. These future sites are outlined in this manner. The hydrological investigations are discussed. This includes the methods used to estimate the run-off for power output and floods. Reservoir operation rule curves are outlined with a discussion of the rule curves in relation to the floods and spillway facilities.

In his paper, ***"Economics of Heavy Water Power Reactors"***, J. R. Dickinson states that from the beginning of reactor work, heavy water has been a neutron moderating material attracting considerable technical interest. Efficient slowing of fast neutrons and a very low absorption cross-section for all neutrons are the two key properties of heavy water which make it an outstanding moderator for thermal reactors. The main adverse feature of heavy water is its current price of $28 per pound. The cost is not so high however to preclude the use of heavy water reactors for economical power operation. In the Canadian program there are three coolant systems judged to have economic merit. Nuclear plants appear attractive to those electrical utilities which have developed their hydro resources and are turning to thermal plants for further system expansion. The nuclear plant is characterized by a high capital cost and low fueling cost whereas the reverse is true for a coal or oil fired plant. In Britain and the United States, graphite reactors, pressurized light water reactors and boiling water reactors have demonstrated plant availabilities of over 90% in first generation plants.

COVER ILLUSTRATION

Symbolizing Power in Canada—the theme of the October Journal—is Grand Falls on the St. John River. At this point the river drops 125 feet. The hydro plant is located a half mile down river. (Photo courtesy the New Brunswick Electric Power Commission.)



and the look of elegance with Nickel-Chrome plating

Nickel-Chrome Plating provides a practical way to win sales . . . it assures distinctive eye-appeal . . . rich with the look of elegance and each touch says "quality"! Nickel-Chrome Plating may be applied to most materials . . . gives designers true flexibility in selecting basic metals for top performance, simplified fabrication and production at a practical cost. In addition, Nickel-Chrome Plating to specification protects the basic metals from rust and corrosion, nicks and scratches . . . adds years of service life to products. Write for a free copy of "Quality Plating."

THE INTERNATIONAL NICKEL COMPANY OF CANADA, LIMITED, 55 YONGE STREET, TORONTO

TAILRACE IMPROVEMENTS AT THE BEAUMONT HYDRO ELECTRIC DEVELOPMENT

C. G. Smallridge, M.E.I.C.,
Hydraulic Engineer,
The Shawinigan Engineering Co. Ltd., Montreal

IN 1959 The Shawinigan Water and Power Company completed its seventh major development on the St. Maurice River at Rapide Beaumont. The Beaumont dam is located approximately 10 miles upstream of the town of La Tuque (Fig. 1) and has a maximum height of 186 ft. The powerhouse contains six generating units in a semi-outdoor arrangement with a total rated capacity of 246,200 kw. at 124 ft. net head.

This paper describes the design and construction aspects of a major tailrace excavation carried out as part of the construction of the development. This excavation enabled a gain in rated head of 17.6 ft. to be realized, which is equivalent to an increase in powerhouse rated capacity of 48,000 kw.

Between the Trenche Development, at river mileage 128, and the La Tuque Development, at mileage 104, the river dropped approximately 135 ft. in an almost continuous rapids section. The Beaumont dam site was selected near mileage 113 because of unfavourable bank topography and geology in the lower section of the reach and controlling grades on the C.N. railway diversion.

Fig. 1. Location Plan.

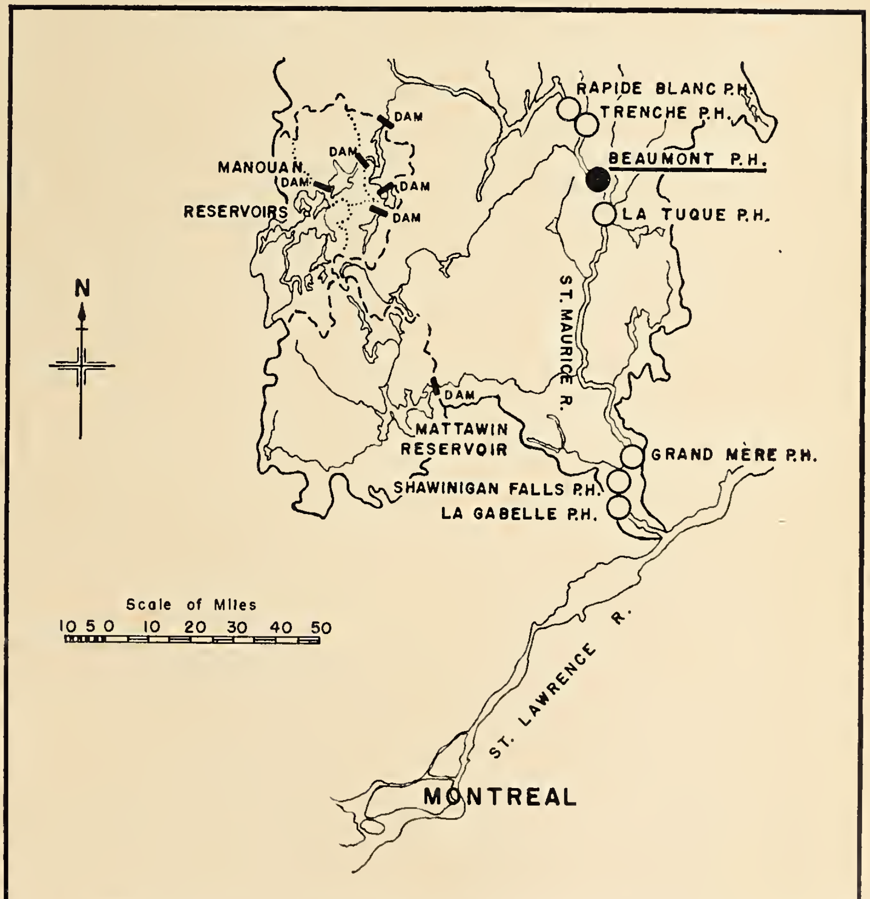


Fig. 2. Boulder Paving on River Bed.

At this point, only 110 ft. of the natural drop was available and studies were therefore initiated to determine the economic feasibility of recovering part of the remaining drop between Beaumont and the La Tuque headpond.

The river bed material consisted of glacial deposits varying from till to coarse sand and boulder, with a general paving of boulders. This paving formed an extremely hard and almost impenetrable crust which hampered preliminary exploration of the river bed material (Fig. 2). Several rock outcrops were in evidence along both river banks.

Preliminary hydraulic studies indicated that a gain in head of 15 ft. was feasible for full powerhouse discharge of 25,000 c.f.s. This required a tailrace channel 175 ft. wide and 20 ft. deep, or of equivalent section, extending from the dam to a point near the foot of the rapids some 2½ miles downstream. It was realized, however, that underwater rock excavation must be avoided in order to recover this head economically. A comprehensive field investigation of seismic and surveying work was therefore set up in conjunction with the investigations at the dam site to determine the bedrock and river bed contours along the proposed channel.

The 2½ mile reach was split into 32 sections which were accurately located in the field and used as reference sections throughout the work (Fig. 3). River bed contours were obtained from the seismic survey and were checked by means of an echo sounder as the excavation progressed.

Method of Excavation

Coincident with the preliminary field work, various methods of carrying out the excavation, such as dredging, excavation from barges and cableways and by means of draglines, were studied in detail and the decision was made to use a large dragline excavator capable of using buckets of at least 10 cu. yd. capacity. Apart from being the most economic solution, this was considered to offer the most versatility under field conditions where local high velocities would be encountered and where the existing bank topography did not allow access to the river from both sides. A suitable dragline with a 165 ft. boom and a 14 cu. yd. bucket capacity was located in Pennsylvania where it had been used for opencast coal operations. This machine weighing 600 tons was purchased, dismantled and loaded on 20 rail freight cars for shipment to Beaumont in the late summer of 1957.

The dragline was reassembled on a site adjacent to the east bank of the St. Maurice River close to Section 10 and was ready to begin excavating by January, 1958 (Fig. 4).

Hydraulic Design

The locations of gauges in the reach of the river below the powerhouse are also shown in Fig. 3. Gauges #3 and #11 at Section 22 indicate the powerhouse tailwater levels at the upstream end of the reach where the increase in head was calculated for the various channel designs considered.

It will be noted that gauges installed in previous seasons had been located only between Sections 17 and 22 at the upstream end, and between Sections 2 and 3 at the downstream end. Water surface profiles along the reach were therefore called for to augment the gauge data and to assist in estimating the natural profiles of the river over a range of flows. This information was used to evaluate the effective roughness of the natural river channel.

Fig. 3. Plan of Tailrace Showing Section Locations.

A series of backwater calculations vas made by a step-by-step method o match the natural water surface profiles using the Manning formula,

$$\frac{h_f}{l} = \frac{n^2 v^2}{2.208 R^{4/3}}$$

and correcting for velocity head changes. Thas was done for different lows and values of Manning's "n" varying from .036 to .055 with various trial assumptions for velocity head loss. The most consistent results were obtained with $n = .055$ and a 50% recovery of velocity head in decelerating flow.

This value of "n" was then corrected for the excavated channel to allow for the reduction in roughness caused by the change in hydraulic radius and the improved channel alignment. The value adopted for the tailrace design was $n = .045$.

The channel was designed to lower the level at Section 22 by 15 ft. for a flow of 25,000 c.f.s. corresponding approximately to the full load flow from six units in the Beaumont powerhouse. Initially it was proposed to excavate the channel from Section 0 to Section 22 and backwaters were worked out for this, but is was found that corresponding backwaters for the same channel cross-section, starting at points as far upstream as Section 2A, converged to give virtually the same conditions upstream. In addition, daily fluctuations in the La Tuque forebay of 1 to 1½ ft. were found to have a negligible effect at Section 2A due to a partial control downstream. Excavation downstream of Section 2A was therefore removed from the schedule.

The variations in river widths and depths to bedrock necessitated three basic channel sections and these were connected by regular transitions to maintain uniform water surface profiles along the channel. Fig. 5 shows a typical section of the excavated channel contained by dikes built from the excavated material. The hydraulic characteristics of the channel sections for the design discharge of 25,000 c.f.s. are shown in Table I.

Fig. 4. Fourteen Cubic Yard Dragline.

The channel was laid out in plan to reduce excavation quantities to a minimum, to avoid bedrock excavaiton and to permit construction of a suitable working road for the dragline with minimum rehandling of material.

Fig. 6 shows the natural water surface profiles and the calculated profiles for the excavated channel at various flows.

In planning the construction work on the channel, numerous problems came to light which led to the decision to construct a hydraulic model of the complete tailrace to determine the optimum method of carrying out the work. A distorted model with a horizontal scale of 1 to 240 and a vertical scale of 1 to 80 was built at the National Research Council, Ottawa, so that alternative methods of carrying out the excavation could be studied in detail. The principal object of the tests was to determine the excavation method which would ensure the greatest lowering of tailwater from the time the first unit came on power without encountering excavation difficulties due to local hydraulic conditions.

The proposed excavation was cast in the model as a series of separate removable blocks so that each stage of the excavation could be studied. To calibrate the model initially, the bed roughness was adjusted until the natural gauge readings were reproduced.

Fig. 7 shows the model in operation under partly excavated conditions with the design flow of 25,000 c.f.s.

Three excavation schemes were proposed for study on the model (Fig. 8). All were governed by the following considerations:—

a) The excavation of the west half of the channel was to be completed before removal of the tailrace cofferdam since the latter formed the only access road to the west side of the river until the powerhouse draft tube deck became available late in the construction period.

b) Economic considerations made it desirable to lower the tailwater as much as possible before the on power date of the first unit.

c) The dragline operation was to proceed smoothly without encountering adverse hydraulic conditions which might hamper progress or cause

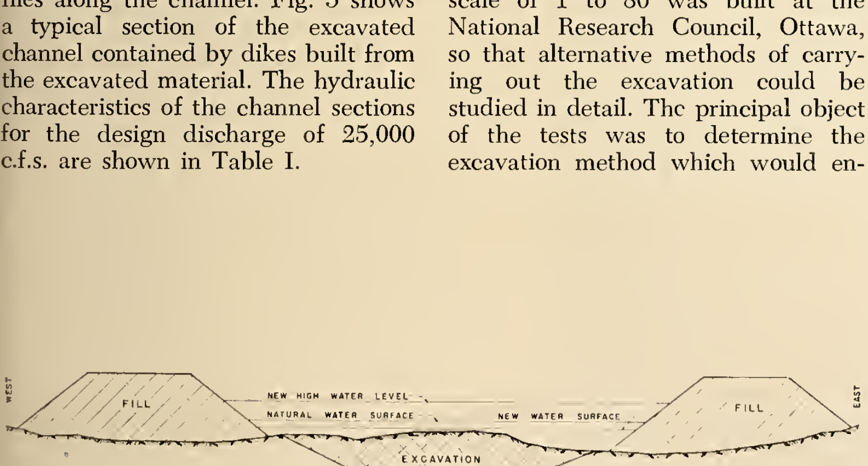


Fig. 5. Typical Section of Tailrace Channel.

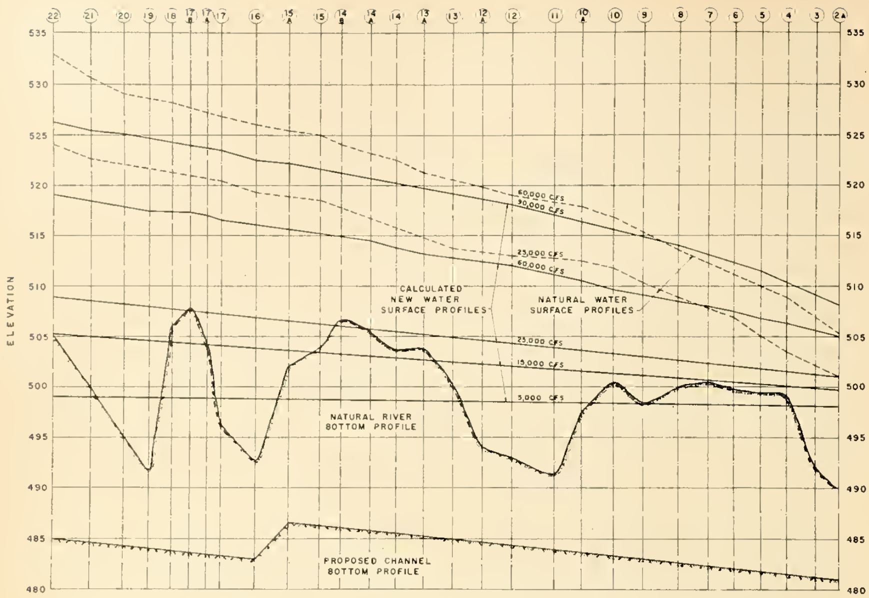
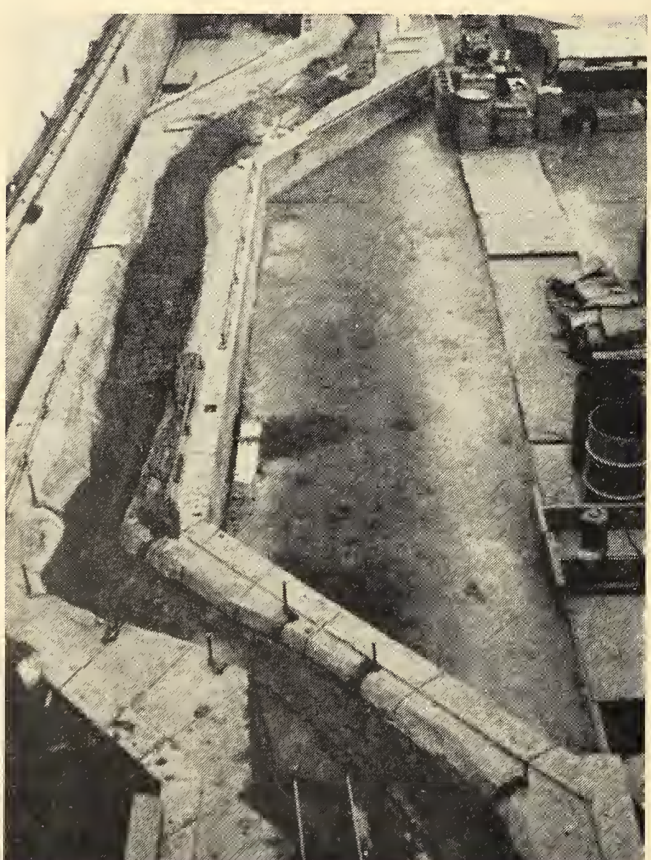


Fig. 6. Water Surface Profiles for Natural and Excavated Channels.

erosion of the roadbed on which the machine moved.

From the model studies, it was apparent that the most appreciable reduction in tailwater level occurred with the excavation of the channel between Sections 17B and 22 and that the gain in head was not significantly different for any of the schemes studied after the on power date of the first unit. This is illustrated in Fig. 8. For reasons of access to the dragline, the actual schedule used was a slight modification of Scheme I.

Fig. 7. Model of Tailrace with Completed Excavation 25,000 c.f.s.



Velocity measurements and visual observations on the model indicated that operation of the dragline would not be affected appreciably by high local velocities for the normal discharge of 25,000 c.f.s. While velocities up to 15 f.p.s. were indicated, these were associated with small depths of flow of the order of 5 to 7 ft.

As the excavation progressed, hydraulic calculations were carried out to evaluate possible changes to the scheme of excavation and to check the design assumptions.

In excavated reaches where subcritical flow prevailed, backwaters were computed by the unit fall method making use of water levels measured in the field and calculated in the original step-by-step calculations.

River Crossings

The method used to travel the dragline across the river was to build a causeway approximately 80 ft. wide and some 8 to 10 ft. above the normal water level. When the causeway reached more than half way across the river, the dragline removed the causeway behind itself and used this material to continue to the other bank.

The initial river crossing was completed at Section 10 without difficulty, and the dragline began the construction of a workroad in the river close to the west bank, upon which it would travel upstream towards the powerhouse. Both the causeway and the work road were constructed with material excavated by the dragline from the river channel and consisting of sand, gravel and boulders which ranged up to a size of 6 cu. yd. each. The excavated material from the new river channel was, in general, to be deposited in dikes on either side of the river to maintain a constant channel width, but with a depth increased in places by up to 25 ft. These dikes were formed on top of the workroads used by the dragline and completed as a final operation before it left each area.

Progress of Excavation

The dragline proceeded upstream and finished the building of the workroad as far as Section 14B an the west bank of the river before the spring flood. At this time high velocities

made it impossible to excavate satisfactorily and caused appreciable erosion at the upstream end of the workroad. While flood conditions existed, it was decided to travel the dragline overland to Section 18, and then to construct the workroad from that point upstream to the powerhouse cofferdam.

The building of this portion of the workroad proved to be the hardest "digging" experienced in the whole project. The material encountered in this section consisted of very large boulders, fine sand, and a compacted sandy silt which could only be "worn down" by repeated passes of the bucket teeth, after which it became a thick black slurry.

From Section 18 to the powerhouse, the new river channel narrowed to conform with the natural limits of the St. Maurice River. The final excavation plans, therefore, required that all excavated material be removed to dumps away from the river's edge, and because of the difficulty in travelling the dragline upstream of Section 16 on the east bank, the complete channel excavation had to be carried out from the west bank of the river.

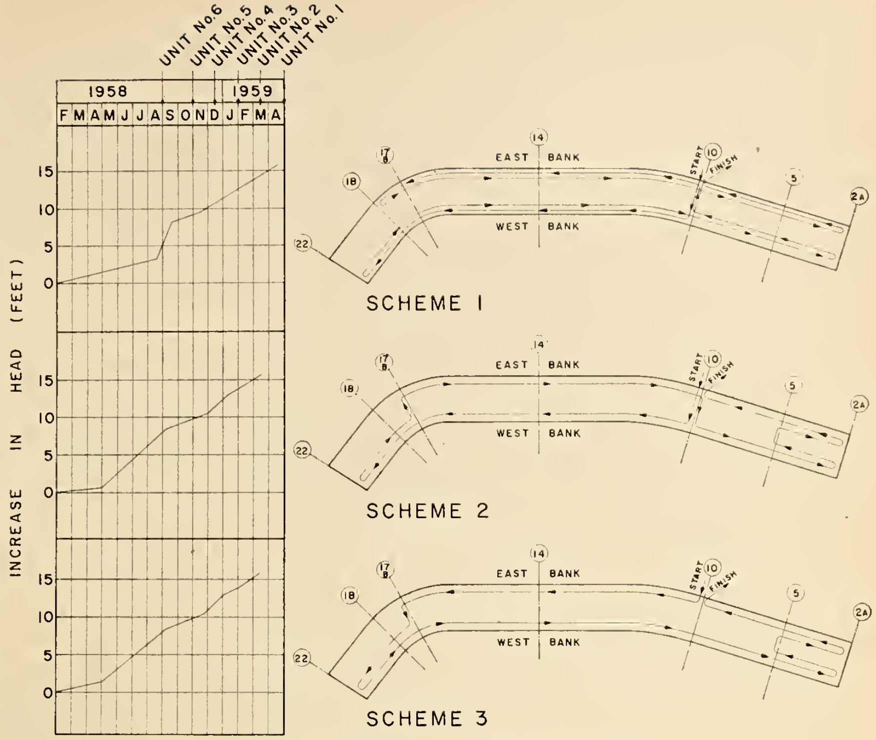


Fig. 8. Alternative Schemes of Excavation.

Because of the nature of the material in the river bed between these sections, it was very difficult to build a suitable workroad for the dragline. The water flowing through the temporary bypass channel at the dam caused higher velocities and greater turbulence at a point where the workroad was formed with the least suitable of materials. Rather than "import" suitable material from elsewhere on the site, the dragline undercut the edge of the west bank of the river which entailed drilling and blasting of rock. At this stage, a heavy steel loading hopper was fabricated and built on site for loading the excavated material from the cofferdam and river channel into 22 ton capacity Euclid trucks. This was built on skids so that two T.D. 24 tractors could move it ahead of the dragline as the excavation of the cofferdam and tailrace channel proceeded.

The excavated material was transported by truck to the main dump for the powerhouse and dam project at about Section 18 on the west bank of the river. After removal of the cofferdam, the dragline began to work it way downstream from the powerhouse tailrace, excavating the road upon which it had been standing and leaving the river channel excavated to the required depth and width. Between Sections 17A and 15A, the excavation of the complete channel width was carried out by the dragline from the west bank, with the bulk of the excavated material being cast on top of the west bank of the river.

The dragline reached the workroad at Section 14B which it had prepared in the previous year and continued the excavation of the west half channel to Section 4 without difficulty, continuing work right through the spring flood of 1959.

It had been decided to cross the dragline from the west bank to the east bank at a point just upstream of Section 5 where the river was very shallow. For this reason, as the drag-

Fig. 9. Tailwater Levels (Section 22).

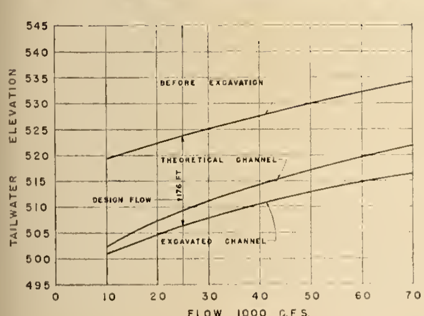


TABLE I

Hydraulic Characteristics of Tailrace Channel

Reach No.	*Length*	*Base Width Ft.*	*Depth of Flow*	*Hydraulic Radius*	$AR^{2/3}$	*Velocity ft./sec.*
I	Sections 19–22 1520 ft.	140	24	18.9	29800	6
II	Sections 18–16 1323 ft.	120	20	17	30400	5.4
III	Sections 2A to 15A—8713 ft.	175	20	15.6	29400	5.4

line moved downstream, no material was removed at the point where the causeway would be constructed. This resulted in high local velocities at the causeway location, and excavation of a bypass channel was decided on to divert some of the river flow away from the main channel. The bypass channel was excavated from a point upstream of Section 3 to Section 6 with the dragline working upstream.

Completion of the bypass channel involved severing land access to the dragline, so this operation was delayed until the actual crossing to the east bank had started. Due to high river flows, the dragline was idle for six days on the island between the bypass channel and the main channel, but after the flows decreased the crossing operation was completed in a similar manner to the previous crossing.

From this point on, the previous procedure was repeated, i.e., the construction of a workroad as the dragline moved upstream and completion to the entire width of the channel on its way downstream. The dragline reached Section 15A on the east side of the river, started working downstream, and completed the excavation to Section 4 without difficulty.

At this stage, the total increase in head gained by the channel excavation at a discharge of 25,000 c.f.s was measured at 16.2 ft. The additional gain in head was largely due to the effect of the bypass at Section 4, but the fact that the actual channel sections were larger than called for in some areas also contributed, as did the improved alignment of the excavated channel. It was therefore decided to excavate only the east half channel between Sections 4 and 2A to complete the work. Following this, the dragline travelled upstream once more along the finished dike as far as Section 10 to the area where it had been assembled 21 months before, and the tailrace improvement for the Beaumont Development was completed.

Final Conditions

The tailwater stage-discharge curves for initial theoretical and actual conditions are shown in Fig. 9. The final increase in head given by the channel excavation at 25,000 c.f.s. was 17.6 ft., equivalent to 16% of the rated net head without tailrace improvement.

During the course of the work on the channel excavation, considerable attention had been paid to the stability of the channel under high flood flows, particularly in view of the large variation in the boulder content of the excavated material.

The excavated channel was put to the test at an early date since the spring flood of 1960, following completion of the work, was one of the highest on record and the channel was subject to flows of up to 105,000 c.f.s.

Water levels were taken along the completed channel periodically during the winter and in particular during the spring flood. It was found that the levels at the powerhouse returned to within 0.1 ft. of their previous values after the flood had receded, leaving a stabilized excavated channel with a very uniform and pleasing appearance.

Table II gives the summary of excavation quantities for the tailrace improvement scheme.

Fig. 10. Tailrace after Completion of Excavation.

TABLE II

Summary of Quantities

	cu. yd.
Actual excavation to form new river channel	2,081,719
Theoretical excavation (original scheme)	1,660,000
Material rehandled	319,000
Construction of causeways	164,856
Total materials handled by 14 cu. yd. dragline	2,565,575
Excavation by small draglines	157,952
Total for Tailrace Improvement Scheme	2,723,527

The incremental cost of the additional rated capacity obtained from the tailrace improvement scheme was \$42/hp.

Acknowledgements

The author would like to express his appreciation to J. C. Godsland Manager of Projects of The Shawinigan Engineering Company Limited, for his many contributions on the construction aspects dealt with in this paper, and to the Division of Mechanical Engineering, National Research Council, Ottawa, for permission to reproduce Fig. 7.

POWER IN CANADA

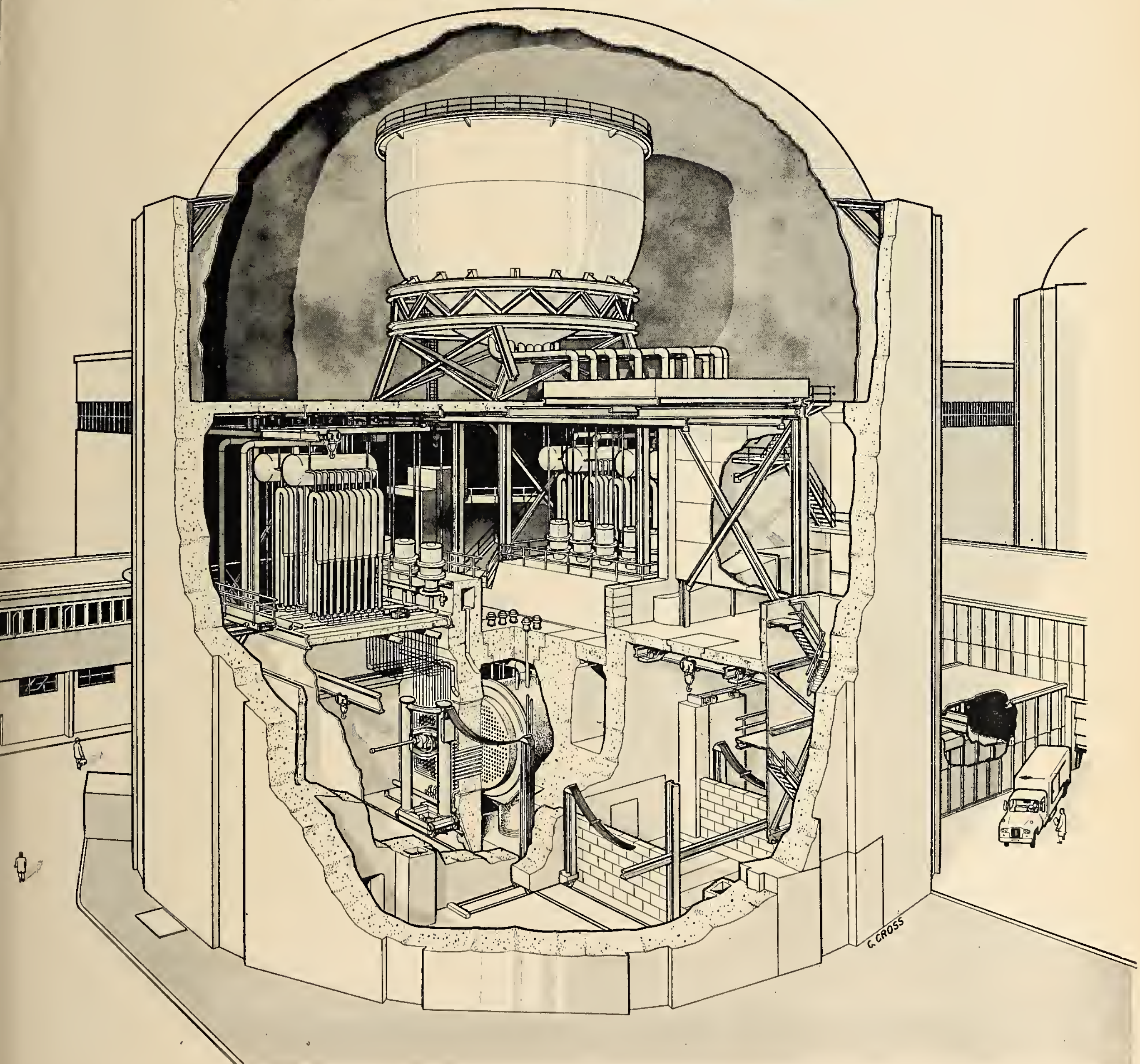
ECONOMICS OF HEAVY WATER POWER REACTORS

J. R. Dickinson,
Civilian Atomic Power Department,
Canadian General Electric Company, Peterborough, Ont.

AROUND THE WORLD, among nuclear workers, the term "heavy water" and the name "Canada" are almost synonymous. This has come about as a result of the straightforward and vigorous way in which the Crown company, Atomic Energy of Canada Limited, with the support of the Canadian manufacturing and utility industries has planned and is carrying through a nuclear power development program suited to this country. Substantial amounts of money are spent year by year working towards the achievement of economic nuclear power. The commitment of resources is a large one for a country the size of Canada but is no more than adequate to support successfully the development of suitable variants of one basic reactor type. The chosen basic type is the heavy water moderated power reactor.

This paper will outline three types

Fig. 1. Cut-away view of 200MW CANDU reactor building at Douglas Point, Ont.



of heavy water moderated power reactor which are part of the Canadian development program for nuclear power. Competitive sources of power and the place for nuclear power in Canadian utility systems are suggested. The paper will close with some comments on the interest of other countries in heavy water power reactors.

Heavy Water Moderator

From the beginning of reactor work, heavy water has been a neutron moderating material attracting considerable technical interest. Efficient slowing down of fast neutrons and a very low absorption cross-section for all neutrons are the two key properties of heavy water which make it an outstanding moderator for thermal reactors. Only graphite and heavy water are practical as moderators for reactors operating on natural uranium fuel; of the two, heavy water has a clear cut advantage over graphite in nuclear properties. To put it another way, a reactor having high neutron economy can be designed using heavy water as a moderator. Good neutron economy in a power reactor is as important as is high thermal efficiency in a steam turbine cycle. Neutron economy will increase as power reactors are improved just as thermal efficiencies have increased as turbines have been improved. Good heavy water moderated reactors have better neutron economy than most other reactor types and this is the basic reason that Canada has concentrated on developing this reactor.

There are other advantages of using heavy water as a moderator. Materials in reactor cores are exposed to intense radiation fields which cause damage and limit their useful life. Not only is heavy water resistant to radiation damage but also the decomposition products of deuterium and oxygen gases can easily be recombined into heavy water. Being a liquid, heavy water does not introduce problems of dimensional changes during irradiation and can also easily be circulated outside the core to remove heat.

The main adverse feature of heavy water is its high cost. During the 1940's and early 1950's production costs as high as $100 per pound caused many to reject heavy water as a nuclear material in spite of its good nuclear properties. The building of a large heavy water production plant in the United States brought the price down to the current $28 per pound. Isakoff[1] has estimated that with process improvements heavy water might be produced for under $20 per pound in the future. Nevertheless, heavy water will remain a substantial cost item which has an important influence on station design and operation. The cost is not so high, however, to preclude the use of heavy water reactors for economical power operation. For a 200 Mw. (electrical) unit about 320,000 lb. of heavy water moderator inventory are required which at the current price, contributes $45 per kw. to the capital cost of the plant. Table 1 indicates the variation of the moderator inventory capital cost with unit size. Providing the remainder of the plant costs are reasonable, and the fuel costs are low, this heavy water inventory charge is quite tolerable.

TABLE 1.
Moderator Inventory Cost

Net electrical output	*Heavy Water Moderator Inventory Cost*
100 Mw.	$53 per Kw.
200	45
300	41

(heavy water taken at $28 per pound.)

Heavy water will be lost during operation during fuel changing, by leakage at valve stems and pump seals, by the changing of resin beds in the ion columns, by residues left in equipment under maintenance, and through accidental spills during handling. Early experience in research reactors indicated such losses might be as high as 3% of the inventory per year or roughly 0.2 mills per kwh. at 80% capacity factor. For power reactors now being designed this seems an unduly pessimistic estimate. By taking care to build leak tight heavy water systems and by backing up these with leakage recovery systems the net cost of heavy water makeup should be under 0.1 mills per kwh. for plants using heavy water as a coolant as well as a moderator, and much less if another coolant is used.

Choice in Coolant Systems

The heat energy generated in the fuel is transported out of the reactor core in the primary coolant system. This heat is supplied to a steam turbine-generator set for conversion to electrical energy. Differences in the design of the primary coolant system can give significantly different reactor designs. In the Canadian program there are three coolant systems judged to have economic merit: heavy water cooling, organic cooling and fog cooling. Each system has its advantages.

The Heavy Water Cooled Plant

The pressurized heavy water coolant system was used first for the NPD reactor and later for the CANDU reactor. Heavy water is pressurized to prevent boiling and is circulated between the reactor core and a steam generator. The flow velocities are high to reduce the heavy water coolant inventory at the expense of pumping power. For a 200 Mw. (electrical) unit an additional heavy water inventory of about 100,000 lb. is needed for the coolant circuit adding another $14 per Kw. to the capital cost of the plant above that for the moderator.

The coolant system operates at a pressure high enough to suppress boiling. At the temperatures of interest the vapour pressure of heavy water is high and increases rapidly for small increases in temperature. In the CANDU plant the coolant system pressure is close to 1500 p.s.i.a. The high system pressure complicates the design and adds to the cost of generating power in several ways. First, the cost of system components is high because heavy components and a high degree of leak tightness are required. Second, the task of changing the fuel which is inside the pressure boundary is more difficult particularly for on-power fuel changing. Third, the thick zircaloy coolant tubes passing through the reactor core are a penalty against the neutron economy and reduce the obtainable fuel burnup.

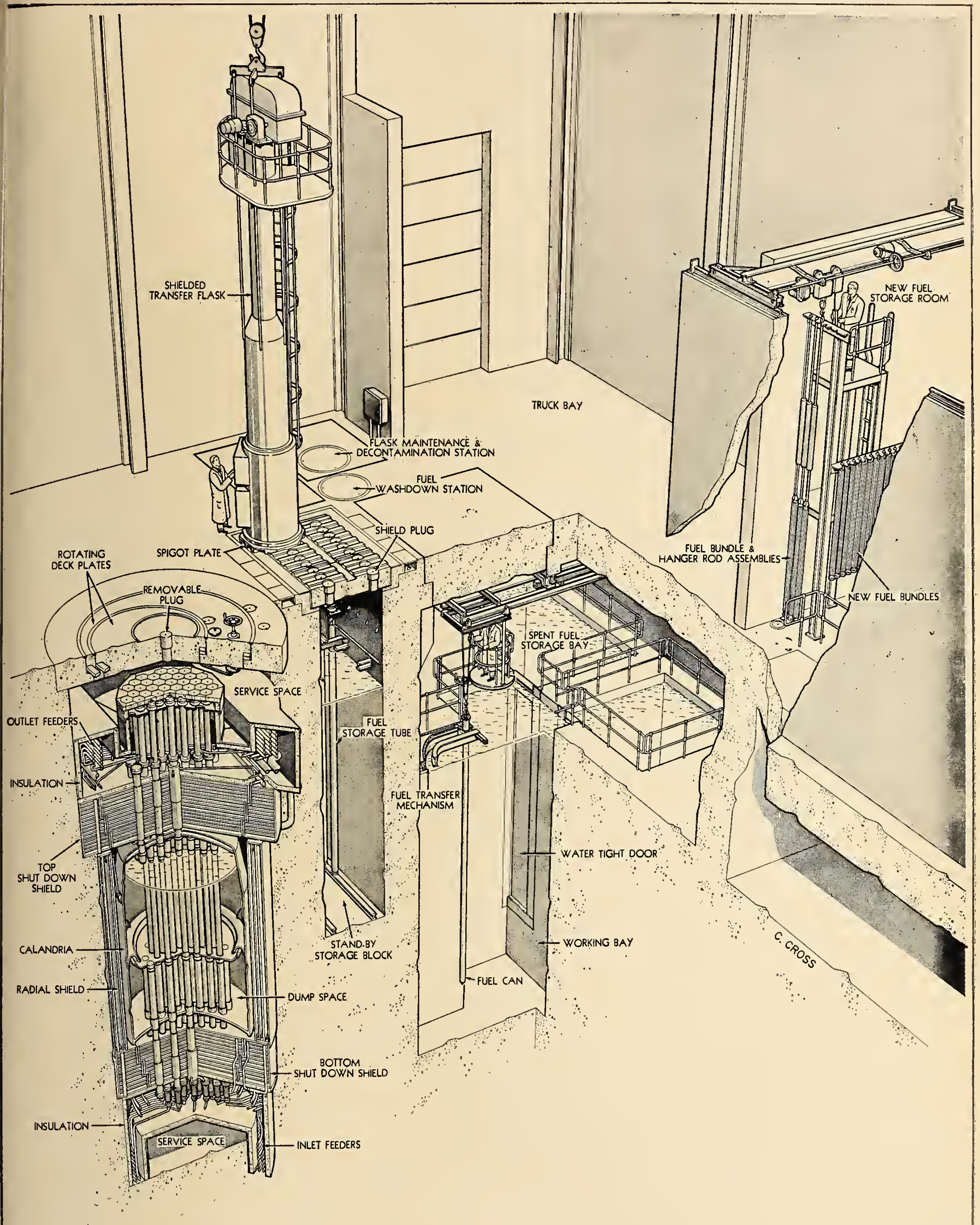
In the CANDU design the coolant leaves the reactor at 560°F. This low outlet temperature is the most important single factor limiting the net station efficiency to about 29%. The outlet temperature is limited by the high temperature properties of the zircaloy-2 alloy used for the reactor coolant tubes. New alloys of zircaloy may allow an outlet temperature as high as 620°F and a net station efficiency of about 31% in future improvements of the heavy water coolant system. The coolant system pressure, however, would be around 2100 p.s.i.a. which is a factor of 1.4 over the present CANDU system pressure. A net station efficiency of 31% is probably an economical upper limit for a plant with a heavy water coolant system.

The reactor core and fuel can be designed not only for a high thermal performance but also for an excellent neutron economy. Fuel bundles of sintered uranium oxide of natural enrichment sheathed in thin-wall zircaloy tubing can reach in the CANDU reactor an average fuel burnup of close to 10,000 MWD/TeU (Megawatt days per metric tonne of contained uranium). At a fuel cost of $30 per pound of oxide the unit fueling cost is 1.1 mills per kwh. Future cost reductions are expected to bring the unit fueling cost under 1.0 mill per kwh.

J. L. Gray[2] states the total capital cost of the 200 Mw. CANDU station to be $408 per kw. Of this, as was

previously noted, about \$59 per kw. is the non-depreciating inventory of heavy water. The remaining plant costs of \$349 per kw. include substantial amounts for nuclear equipment, special conventional equipment, and engineering development. These are all areas where the experience gained in the NPD and CANDU projects will point the way to substantial cost reductions in future plants of the CANDU type. Extrapolating from

Fig. 2. Cut-away view of OTR reactor at the new Whiteshell research centre.



British and American reactor experience and excluding heavy water, the future cost might fall by almost 30% to \$250 per Kw. If at that time heavy water can be purchased at \$20 per pound the total capital cost would be about \$290 per kw. for a 200 Mw. (net electrical) plant.

The operating costs of the CANDU plant, other than fuel, are estimated to be about 1.0 mill per kwh. This estimate is probably conservative but operating time in the NPD and CANDU plants is needed before the operating costs can be better established.

The total unit energy costs resulting from all these estimates is summarized in Table 2. The unit costs are based on a 200 Mw. station with a capacity factor of 80% and a composite annual capital charge rate of 6.5%. The future cost is only a reasonable objective; it is not a firm estimate. The capital charge rate is reasonable for public utilities.

TABLE 2

CANDU Unit Energy Costs

	Present	*Future*
Unit capital cost	3.9	2.7
Unit fueling cost	1.1	1.0
Unit operation and maintenance	1.0	1.0
Total unit energy cost	6.0	4.7 mill per kwh

The OCDR Organic Cooled Plant

Organic materials of the terphenyl family have two properties which make them attractive for use as a reactor coolant. First, the terphenyls have a low vapour pressure allowing coolant systems to be operated at low pressures even at temperatures up to 800°F. Second, the terphenyls are a byproduct of petroleum refining costing in the range of 12 to 53 cents per pound. In comparison with heavy water coolant, organic coolant with these properties offer the potential for substantial cost savings. The coolant system operating pressure can be under 300 p.s.i.a. and the organic inventory in the coolant system contributes less than \$1 per kw. to the capital cost of an OCDR plant.[5]

Organic coolants are damaged by high temperatures and also by radiation in a reactor core. The pyrolytic damage rate is not significant at temperatures under about 750°F. The radiolytic damage rate is significant at all temperatures. The high boiler damage products are removed from the coolant by distillation during operation and are replaced with fresh organic at the rate of about 0.6×10^{-3} pounds per kwh. of power generated. At a makeup coolant cost of 53 cents per pound this represents a unit operating cost of about 0.3 mill per kwh. By reclaiming part of the high boiler damage products and by using a cheaper makeup coolant it may be possible to cut this operating cost in half.

The onset of pyrolytic damage in the organic as bulk temperatures rise above 750°F limits the reactor coolant outlet temperature to about 770°F. At this coolant temperature a net station efficiency of about 36% is obtainable. The temperatures are high enough to permit a superheated steam cycle with one stage of reheat.

Uranium oxide fuel of natural enrichment can be used in an OCDR reactor. The nuclear properties of the organic coolant are not as favourable as those of heavy water and the neutron economy suffers. An average fuel burnup of about 6600 MWD/TeU can be expected. The fuel can be sheathed in SAP material (sintered aluminum pulver) at a cost in the order of \$25 per pound. The resulting unit fuelling cost is about 1.0 mill per kwh.

Uranium carbide is an alternative fuel which can be considered for use with organic coolants but not with water coolants. With uranium carbide the neutron economy of the reactor can be improved and the average fuel burnup can be increased to 8600 MWD/TeU. The cost of producing uranium carbide fuel is not well established nor is the technical feasibility fully demonstrated but a unit cost of under 0.8 mill per kwh. may be possible.

The total capital cost of a 200 Mw. OCDR station is estimated to be about \$312 per kw. Of this about \$45 per kw. is the non-depreciating inventory of heavy water. This cost estimate is intended to be on the same basis as the first CANDU cost estimate but it is worth stressing that not only do the figures come from two different engineering groups but also the CANDU plant is well along in construction whereas the OCDR plant is in an earlier phase of engineering study and component development. The heavy water inventory cost would reduce to \$32 per kw. if heavy water could be obtained for \$20 per pound. Also the benefit of experience in building an OCDR plant would lead to cost reductions in the remainder of the plant. In the long term OCDR plants of 200 Mw. might be built for under \$250 per kw. including heavy water.

The operating costs for an OCDR plant, other than fuel, heavy water losses, and organic coolant replacement, should be comparable with those for CANDU. Heavy water losses should be considerably less because there are no high pressure systems.

The total unit energy cost resulting from all these estimates for OCDR is summarized in Table 3. The unit costs are based on a station capacity factor of 80% and a composite annual capital charge rate of 6.5%. Once again it should be emphasized that the future cost is only a reasonable objective, not a firm estimate.

TABLE 3

OCDR Unit Energy Costs

	Present	*Future*
Unit capital cost	2.9	2.4
Unit fueling	1.0	0.8
Unit organic makeup	0.3	0.2
Unit operation and maintenance	0.9	0.9
	5.1	4.3 mill per kwh

The cost estimates presented here seem to give the OCDR concept a definite advantage over the CANDU concept. OCDR is at a much earlier stage of development than CANDU, however, and this makes it impossible to reject one in favour of the other on any logical basis. Certainly the promise in the OCDR concept cannot be ignored and development work on organic coolants is justified. The OTR (Organic Test Reactor) to be built at Whiteshell, Man. is designed to give the engineering information on which to base the design of OCDR power stations.

The Fog Cooled Plant

The fog cooled reactor concept[3] is the most recent coolant system to be added to the Canadian nuclear power development program. The amount of work done so far is nowhere near the amount done on heavy water cooling or organic cooling and therefore fog cooling cannot be compared with these other two except in a preliminary way.

Fog cooling is only one of several names which have been used to describe a form of wet steam cooling. Water is injected into steam at the inlet of a fuel channel. The water is carried through the channel as suspended droplets in the steam and as a film of liquid on the surface of the channel. Some of the water is converted to steam as heat is added from the fuel. The remaining water is removed from the steam on leaving the reactor and is recirculated. The dry saturated steam passes directly from the reactor to a steam turbine in a direct cycle. In contrast, both the

pressurized heavy water cooling and the organic cooling are used in indirect cycles with a steam generator between the reactor and the turbine.

The amount of coolant material in the reactor core is low enough that ordinary water can be used. Some penalty in neutron economy results but an average fuel burnup of up to 9000 MWD/TeU should be possible with natural uranium fuel. The fuel would be very similar to the CANDU type of fuel.

The high temperature properties of zirconium alloys would limit the coolant temperature leaving the reactor to the same order of magnitude as for pressurized heavy water cooling but the elimination of the temperature drop in the steam generator should allow a net station efficiency of 32% to be obtained in comparison with 29% in CANDU. Higher net station efficiencies may be possible so that the fueling cost for a fog cooled reactor may be 0.1 mill per kwh. lower than for CANDU.

The elimination of the heavy water coolant inventory gives a $14 per kw. capital cost advantage over CANDU; the elimination of the steam generators and other equipment may give a further $10 to $15 per kw. capital cost advantage. The capital cost of a 200 Mw. fog cooled reactor may be, therefore, in the order of $280 per kw.

Since heavy water is not used in a high pressure circuit it may be possible to eliminate the CANDU allowance of 0.1 mill per kwh for losses.

These cost estimates are very crude but show the reason for interest in fog cooling. The total unit energy costs for a 200 Mw. station at 80% capacity factor and a composite annual capital charge rate of 6.5% are shown in Table 4.

TABLE 4

Fog Cooled Station Unit Energy Costs

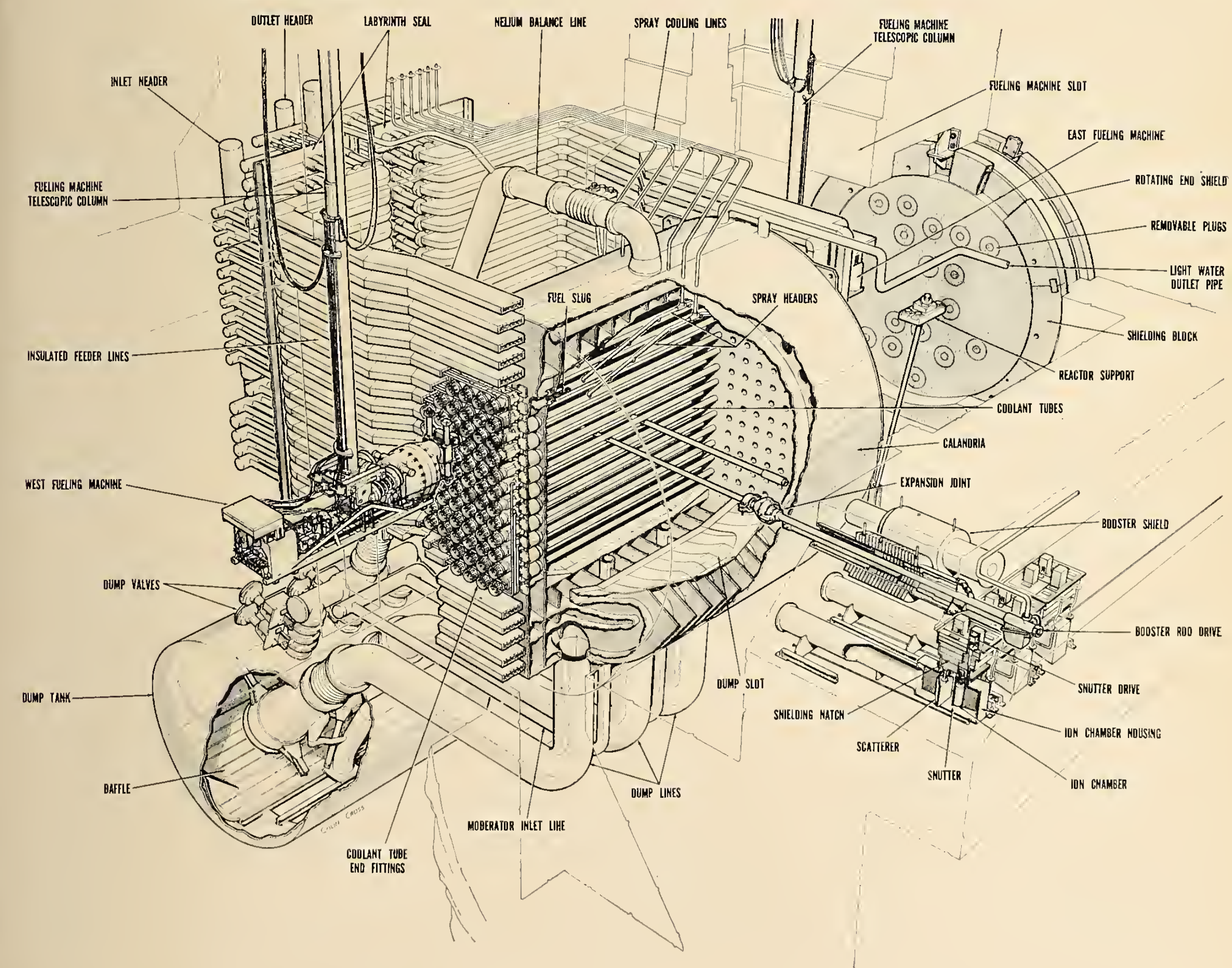
Unit capital cost	3-6–2.4
Unit fueling cost	1.0
Unit operation and maintenance	0.9
Total unit energy cost	5.5–4.3 mill per kwh

The final position of fog cooling relative to organic cooling is very dependent on the degree of success in the respective development programs. One advantage of fog cooling is that the development work in fuel and materials is an extension of the substantial existing programs for the CANDU reactor. The OCDR concept relies on materials which are new in the Canadian nuclear program. On the other hand, the development problems with organic cooling are now fairly clearly defined, whereas the problems to be faced in fog cooling are not yet clear. These and other intangible factors must be evaluated along with the economic evaluations.

Nuclear Plants in Utility Systems

Nuclear plants appear to be attractive only to those electrical utilities which have developed their hydro resources and are turning to thermal plants for further system expansion. The Hydro Electric Power Commission of Ontario has reached this position and before 1970 many other large utilities in Canada will also be in this position. The choice in thermal plants will be largely between coal-fired stations and nuclear stations.

Fig. 3. Cut-away view of 20MW NPD reactor showing nuclear replacement for coal-fired boiler.



H. A. Smith has estimated current coal-fired costs for 80% capacity factor to be 4.4 mill per kwh. as shown in Table 5 for 300 Mw. units in a multiple unit plant. The interest rate is the same as for the nuclear plant estimates.

TABLE 5

Coal-Fired Plant Unit Energy Costs

Unit capital cost	1.0
Unit fueling cost	3.1
Unit operating and maintenance	0.3
Total unit energy cost	4.4 mill per kwh

H. A. Smith also estimates[4] that about 12,000 Mw. of some type of thermal capacity will be needed in Ontario in the next twenty years and that about 60% of this capacity will be required to operate at relatively high capacity factor. The nuclear plant is characterized by a high capital cost and a low fueling cost whereas the reverse is true for a coal or oil-fired plant. The nuclear plant must operate at high capacity factor if it is to compete with a coal-fired plant. Nuclear plants could, therefore, supply up to 7,200 Mw. of the 12,000 Mw. needed.

The historical pattern in an all coal-fired plant system has been that the newest unit is the largest and most efficient and, therefore, begins operation at a capacity factor close to 90%. As newer more efficient units are added the capacity factor on the older units drops steadily until after many years a unit is too small and expensive to keep in operation. The lifetime average capacity factor is close to 50%; the lifetime average weighted by present worth at the time of commissioning is over 60%. The same trend but to a much less severe degree will occur with nuclear plants. Since nuclear plants will not be the only type of generation on the system it is quite probable that the capacity factor weighted by present worth will be as high as the 80% value which has been traditional in most evaluations of nuclear power.

The historical improvement in coal or oil-fired station heat rates is slowing down and a new trend towards a mix of types of generation is emerging. For example, it may be cheaper to achieve 50% load factor by installing one gas turbine plant for 20% capacity factor and one nuclear station for 80% capacity factor than it would be to install all the capacity in coal fired units.

Hydro generation can sometimes be an inexpensive peaking generation. The incremental cost of adding capacity at a given hydro site is often quite low. Assuming that suitable water storage capacity can be provided it is reasonable to design the hydro plant for eventual low load factor operation. It is then possible to add units for peaking capacity at hydro sites and units for base load operaiton at nuclear stations.

It is only very recently that operating experience has been obtained on nuclear power plants. In Britain and in the United States graphite reactors, pressurized light water reactors and boiling water reactors have demonstrated plant availabilities of over 90% in first generation plants. The operation of NPD will soon begin to show what might be expected from a heavy water moderated reactor; an equally good performance is expected.

Finally, nuclear plants are more economical in large sizes. The influence of unit size on the total unit energy cost is illustrated in Table 6. Most Canadian utilities could use 100 Mw. units and some, such as Ontario HEPC, could use 300 Mw. units or larger. Because of their high capital cost nuclear plants benefit more from an increase in size than do coal-fired plants.

TABLE 6

Influence of OCDR Unit Size

Unit	*Total Unit Energy Cost Present*	*Future*
		mill per kwh.
100 Mw.	6.9	5.7
200	5.1	4.3
300	4.5	3.8

Heavy Water Reactors in Other Countries

The Canadian nuclear power program is founded on the belief that the high neutron economy of the heavy water reactor will carry this reactor type to a preferred position. In the United States the availability of substantial amounts of enriched uranium on loan has diverted attention away from high neutron economy. In a 1961 year-end review of United States civilian power reactors, J. A. Lane concludes[6] ". . . with the prospect of private fuel ownership in the offing, those developing civilian power reactors should take a more serious look at alternative approaches aimed at higher neutron economy". In the same article he says, "Even natural uranium, heavy water moderated plants have come into the competitive picture".

In Britain where a considerable nuclear power program has been built on graphite moderated reactors, Sir Christopher Hinton has recently reviewed the program[7] and has pointed to technical difficulties with the use of graphite. He concludes that consideration should be given to the use of heavy water moderated plants. This statement came on returning to Britain after a review of the Canadian progress in nuclear power.

Sweden, France, Spain, Norway, Denmark, Germany, EURATOM, and India all have an interest in heavy water moderated power reactors. There is a variety of approaches in these countries: EURATOM proposes organic coolant for their ORGEL reactor; Sweden prefers the pressure vessel type over the pressure tube type; France proposes gas cooling; Norway has a boiling heavy water reactor at Halden. All are agreed, however, that there is merit in using heavy water.

Long Term Prospects

So far the nuclear power prospects in the next 10 years have been discussed. In the longer term Dr. W. B. Lewis[8] foresees that the heavy water natural uranium reactor seems likely not only to derive a burn-up of 10,000 MWD/TeU but also to have a net station efficiency of 45%. He expects the heavy water inventory, with low financing charges, to contribute only 0.15 mill per kwh. to the total unit energy cost and he expects the fueling cost to be reduced drastically. The capital costs will be low enough for nuclear plants to beat coal-fired plants even at 50% capacity factor. This is a challenging objective.

The key to obtaining a very high net station efficiency is the successful development of nuclear superheat for use in combination with either organic cooling or fog cooling. Using stainless steel fuel sheathing it may be possible to reach a top coolant temperature of 1200°F at 3000 p.s.i.a. and thus achieve a steam cycle as advanced as any in use in modern coal-fired plants. If this can be done without too great a penalty in neutron economy then the heavy water moderated power reactor will indeed be a difficult plant for others to compete with.

References:

1. Isakoff, L. **Economic Potential for D_2O Power Reactors,** February 1961, AEC report DP-570.
2. Gray, J. L. **Presentation To The House of Commons Special Committee on Research** 1961, Publication AECL-1000.
3. Pon, G. A. **Fog Cooled Heavy Water Moderated Reactors** September 1961, Publication AECL 1318, paper 10.
4. Smith, H. A. **Nuclear Power In the Hydro System** September 1961, Publication AECL 1318, paper 7.
5. Dickinson, J. R. and Scarth, R. F. **OCDR Power Plant Study** October 1960, Canadian General Electric Company technical report R60CAP67.
6. Lane, J. A. **Civilian Power Reactors** Nucleonics, January 1962.
7. Hinton, Sir Christopher **Nuclear Power** The Three Banks Review, No. 52, December 1961.
8. Lewis, W. B. **Long Term Prospects For Competitive Nuclear Power** September 1961, publication AECL 1318, paper 11.

EIC

ASPECTS OF THE BACKGROUND OF COLUMBIA RIVER PROJECTS IN CANADA

R. C. McMordie, M.E.I.C., *British Columbia Hydro and Power Authority.*

THE COLUMBIA RIVER is the fourth largest river in North America. In length and flow it is exceeded only by the Mississippi, MacKenzie and St. Lawrence Rivers. The drainage basin of the Columbia River has an area of 259,000 sq. miles, 39,500 sq. miles being in Canada. The Canadian drainage area can be subdivided as follows:

	sq. mi.
Columbia River main stem	14,440
Kootenay	14,500
Pend d'Oreille	1,200
Okanagan, Similkameen, Kettle and others	9,360
Total	39,500

Between its source in Columbia Lake and its outlet at sea level the main stem of the river falls 2,650 ft., 1,360 ft. of this being in Canada and 1,290 ft. in the United States. The average flow of the river at its mouth is 220,000 c.f.s., and 97,000 c.f.s. where it crosses the Canada-U.S. border. The flow at the border includes the discharges into the Columbia of its tributaries, the Kootenay and the Pend d'Oreille, a substantial part of whose drainage basins is in the United States.

Fig. 1.

Figs. 1 and 2 are respectively a general map and a profile of the Columbia River and its more important tributaries.

Existing and Potential Power Developments on the Columbia River

During the past 30 years a rapid growth in economic and industrial development has occurred in the Pacific Northwest of the United States. This growth can be attributed, in part at least, to the availability of abundant low cost hydro-electric power resulting from the development of a considerable portion of the hydro-electric potential of the Columbia River and its tributaries in the United States. On the main stem of the river

	Gross Head feet	*Installation plant kw (name-plate)*	*Date Completed*
Rock Island Project	38	212,100	1933
Bonneville	59	518,400	1938
Grand Coulee	343	1,944,000	1941
McNary	75	980,000	1953
Chief Joseph	171	1,024,000	1955
The Dalles	86	1,119,000	1957
Priest Rapids	80	788,500	1961
Rocky Reach	93	711,550	1961
Wanapum	84	831,250	*
John Day	104	1,080,000	*
Wells (proposed)	68	400,000	
Totals	1,201	9,608,800	

*Under construction

1,133 ft. of head has been utilized or is in course of active development, the total installation being nearly 10 million kw.; including tributaries, this total is more than 11 million kw.

Existing plants, those under construction and one proposed plant all on the main stem of the Columbia River in the United States, are listed in the tabulation shown on Page 1.

The full potential of the Columbia River in the U.S., including tributaries, is in the order of 35 million kw. of installed capacity.

In Canada the most significant existing power developments lie in the 350 ft. of head on the Kootenay River downstream from Kootenay Lake, and the 210 ft. at Waneta on the Pend d'Oreille. Although approximately 417,000 kw. of nameplate capacity has been developed on these two tributaries, no power development has been made as yet on the main stem of the Columbia. The ultimate potential of the Columbia River and its tributaries in Canada is approximately six million kw. installed capacity or 3.5 million kw. of prime power not including downstream benefits. The significance of this to the economy of British Columbia can be appreciated when it is compared with the present total hydro-electric and thermal generating capacity in Southern B.C. of 2.4 million kw. installed or under construction.

Flow Regulation of Columbia River

The flow of the Columbia River and its tributaries fluctuates widely. At the International boundary extremes of 550,000 c.f.s. and about 14,000 c.f.s. have been recorded. Some improvement in the flow in the United States has been made as a result of the construction of several storage reservoirs, the most important being the following:

	million acre feet
Hungry Horse	3.16*
Kerr	1.22
Albeni Falls	1.16
Grand Coulee	5.23†
Total	10.77

*3,008,000 acre feet at normal full pool elevation of 3,560.

†5,072,000 acre feet without flash boards at normal full pool elevation of 1,288.

There now exists over 13 m.a.f. for regulating purposes on the Columbia River, all in the U.S. except for 673,000 acre feet of storage presently usable in Kootenay Lake in Canada under the current I.J.C. order. This storage, however, is far from adequate to provide the amount of flow regulation required for power and flood control. The United States Corps of Engineers has recommended a total of 32 m.a.f. for these purposes. Since practically all the available head on the main stem is now under development, provision of additional storage is urgently required.

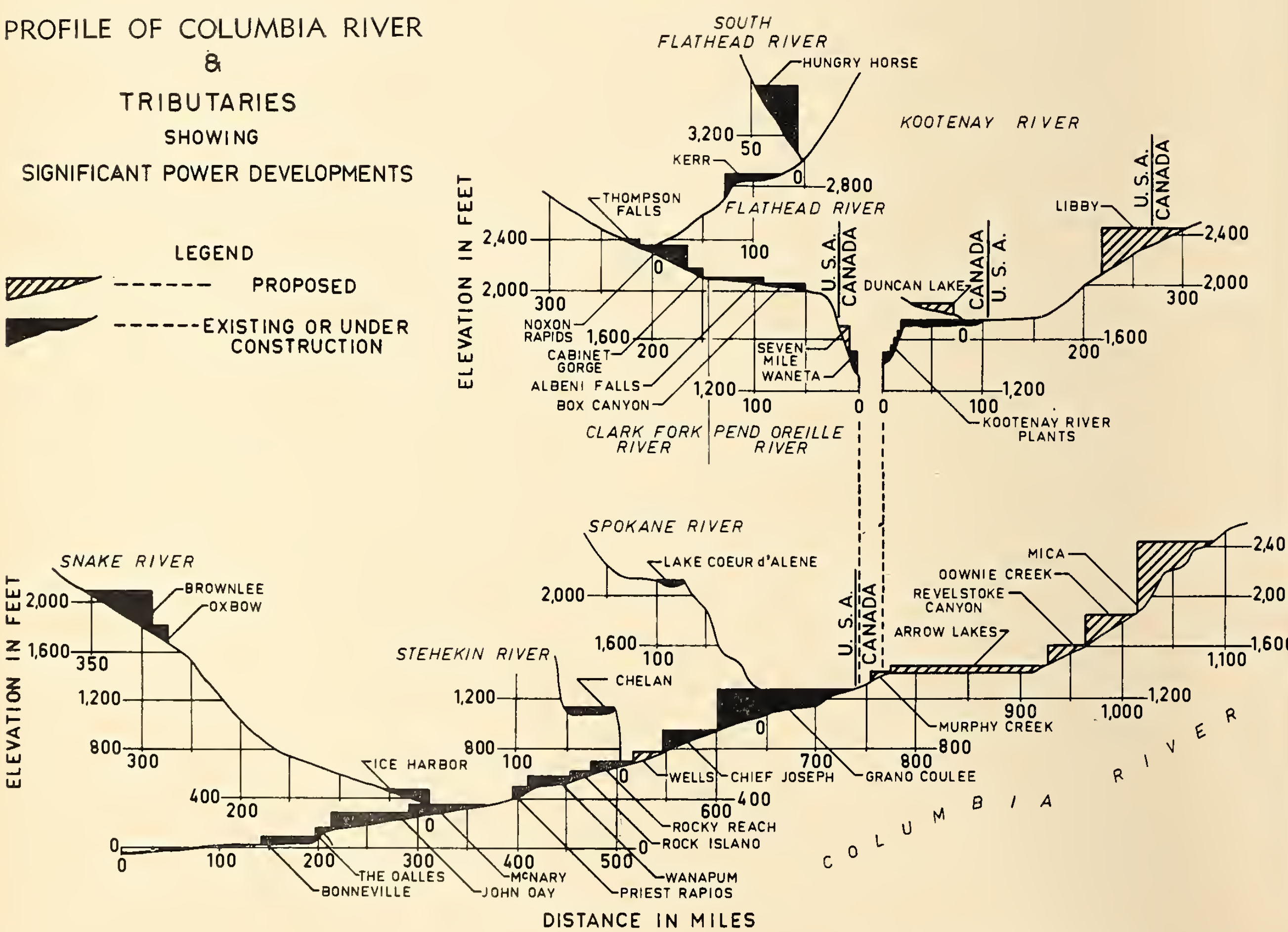
By far the lowest cost sources of additional storage on the Columbia River are located in Canada. The international problem therefore was to determine how these storages could be best developed to the mutual advantage of both Canada and the United States.

Features of Columbia River in Canada

Before proceeding to outline the steps followed in arriving at a Columbia River Treaty with the U.S. it may be appropriate to outline very briefly characteristic features of the Canadian section of the Columbia.

1. The proximity of the Upper Columbia and Kootenay River at Canal Flats, which provides the possibility for a relatively economi-

Fig. 2.



cal diversion of water from the Kootenay into the Columbia.

2. The large flow contribution of the Upper Columbia, together with the substantial 1,000 ft. head drop in the "Big Bend" route which the river follows as it flows from the Rocky Mountain Trench through the Selkirk Mountains.
3. The Upper and Lower Arrow Lakes system, which provides features for a large, economical storage reservoir, especially valuable for regulation of water releases from any Canadian generating plants such as Mica.
4. The Kootenay and Duncan Lake System. Kootenay Lake provides regulation for power purposes on the Kootenay River, and in addition, Duncan Lake storage can be developed to provide downstream power and flood control benefits in the U.S. and to the generating plants on the Kootenay River in B.C.
5. The relatively short, 16-mile section of the Pend d'Oreille River which falls 426 ft. in Canada. Storage to control the flow of the Pend d'Oreille River is in the United States and is operated primarily to improve the flow in the main stem of the Columbia River. Storage releases occur in the Winter when power is most needed, but the late Summer flows are at present so reduced that output from Canadian generating plants is limited during this period.

International Joint Commission — Report on Engineering Studies

On March 9, 1944, the Governments of Canada and the United States referred to the International Joint Commission the problem of determining whether or not a greater use than is now being made of the waters of the Columbia river system would be feasible and advantageous to both countries. The Commission was instructed to study the water resources of the Columbia River basin, having in mind water supply, navigation, efficient development of water power, control of floods, the needs of irrigation, reclamation of swamp lands, and conservation of fish and wildlife.

To assist it in carrying out this assignment, the International Joint Commission established the International Columbia River Engineering Board, consisting of four engineers chosen in equal numbers from the Federal services of Canada and the United States. On March 1, 1959, the International Columbia River Engineering Board presented its report entitled "Water Resources of the Columbia River Basin".

In making its studies of the Columbia River, the International Joint Commission was instructed to consider the river as a whole and as if no international boundary existed. The object of this instruction presumably was to simplify the problem by ensuring that only engineering aspects, and not particular national or political problems, were to be considered. This limitation was recognized by the writers of the report, as is noted in some of its conclusions, as follows:

"(l) The method of co-operative development of the Kootenay and Upper Columbia Rivers will be determined by considerations beyond the scope of this report, but the information provided herein on the alternative plans will provide a reasonable basis for discussion between the two countries."

"(n) In the case of alternative projects, their respective dates of completion may be the deciding factor and hence the choice of projects may depend upon consideration of the time factor. In this report, however, all projects were considered as constructed simultaneously."

"(p) For any further progress towards co-operative development, some measure of general agreement between the two countries should be reached with respect to principles for sharing benefits and costs. Project justification requires the use of such principles to determine the benefits and costs to be ascribed to individual components of an agreed plan of development."

"(r) Orderly development of the water resources of a basin normally requires that the most economically attractive projects be constructed first; this process cannot be followed completely in the case of the Columbia River basin unless co-operative development is made possible by international agreement."

International Joint Commission — Report on Principles

Partly in view of the limitations as noted in the basis of the International Columbia River Engineering Board's report, the Governments of Canada and the United States agreed that, before commencing negotiations, basic principles should be established which it was hoped might lead to co-operative development of the resources of the Columbia River. The International Joint Commission was accordingly instructed to prepare a special report giving "its recommendations concerning the principles to be applied in determining:

(a) The benefits which will result from the co-operative use of storage of waters and electrical interconnection within the Columbia River system; and

(b) The apportionment between the two countries of such benefits more particularly in regard to electrical generation and flood control."

The Commission submitted its report on this reference on December 29, 1959. In this report the International Joint Commission noted the possibilities for co-operative development in the Columbia River basin that could be of mutual advantage to the two countries. It enunciated three basic general principles which should apply to such co-operative development.

1. "Co-operative development of the water resources of the Columbia River Basin, designed to provide optimum benefits to each country, requires that the storage facilities and downstream power production facilities proposed by the respective countries will, to the extent that it is practicable and feasible to do so, be added in the order of the most favourable benefit-cost ratio, with due consideration of factors not reflected in the ratio".

2. "Co-operative development of the water resources of the Columbia River Basin should result in advantages in power supply, flood control, or other benefits, or savings in costs to each country as compared with alternatives available to that country".

A third general principle relating to the trans-boundary projects read as follows:

3. "With respect to trans-boundary projects in the Columbia basin, which are subject to the provisions of Article IV of the Boundary Waters Treaty of 1909, the entitlement of each country to participate in the development and to share in the downstream benefits resulting from storage, and in power generated at site, should be determined by crediting to each country such portion of the storage capacity and head potential of the project as may be mutually agreed".

It will be noted that this principle does not in effect suggest any basis for international co-operation on trans-boundary projects, but leaves this open for negotiation.

In addition to stating the three general principles, the International Joint Commission enunciated seven particular principles dealing with power and six principles dealing with flood control. These principles deal with important matters such as the sequence of projects, the division of additional power output between the two countries, electrical interconnection and payment for flood control.

Negotiations Leading to the Columbia River Treaty

Following completion of the report on principles by the International Joint Commission, representatives of the Governments of Canada, B.C. and the United States, commenced negotiations regarding the terms of a Columbia River Agreement.

Both groups of negotiators adopted the principles set forth by the International Joint Commission as a basis and guide to their deliberations. In applying these principles, however, two fundamental aspects gave rise to prolonged discussion, namely:

1. The determination of the quantity of storage under General Principle No. 2, which it would be economically sound to accept for co-operative developments; and

2. The sequence of storage projects.

On September 28, 1960, the negotiators reported "that agreement has been reached between them on the basic terms which in their opinion should be included in an agreement for the co-operative development of the water resources of the Columbia River Basin that will operate to the mutual advantage of both countries". They recommended that the agreement should be in the form of a treaty and provided the Governments with a series of proposals to be used to form the basis of the Treaty.

Subject to certain changes these proposals constituted the basis of the Treaty as subsequently negotiated and signed by representatives of the Governments of Canada and U.S.A. on January 17, 1961.

It is now proposed, as briefly as possible, to review, but with little comment, the main provisions of the Treaty, having in mind particularly their engineering aspects.

Columbia River Treaty

Undertakings by Canada and U.S.A.

The objective of the Columbia River Treaty is to facilitate the undertaking of co-operative measures by Canada and the U.S.A. for hydro-electric power generation and flood control on the Columbia River and its tributaries. With this objective Canada undertakes to provide 15.5 million acre feet of storage to be used for improving the river flow. This is to be done by constructing dams on the Columbia River near Mica Creek, with 7 m.a.f. of storage, on Arrow Lakes with 7.1 m.a.f. of storage and on the Kootenay River at Duncan Lake with 1.4 m.a.f. Canada undertakes to operate these reservoirs in accordance with principles set forth in the Treaty so as to provide defined flood control on the Columbia River in the U.S.A., and consistently with the flood control requirements, to produce maximum downstream power benefits. Provision is made for the operation later to conform also to the load shape of future generating requirements in Canada.

In return for this undertaking on the part of Canada, the United States agrees to make available to Canada one half of the downstream power benefits in the U.S. resulting from operation of the Canadian storage as next added to the existing base system in the United States. Canada's entitlement to downstream benefit power will be delivered, less transmission loss, to Canada at a point on the Canada-U.S. boundary near Oliver, B.C.

The United States will also pay Canada in respect of flood control benefits—\$11.1 million on completion of Duncan Lake storage, \$52.1 million on completion of Arrow Lakes storage and \$1.2 million on completion of Mica Creek storage. These payments are based on the volume of water controlled in Canada in relation to the total volume in the whole Columbia basin, the objective being to reduce a major flood such as occurred at the Dalles in 1894 from 1,240,000 c.f.s. to 800,000 c.f.s. Further, the U.S. can request and Canada will provide, if facilities exist, additional flood control during the term of the Treaty, on the basis that the U.S. will reimburse Canada any costs incurred thereby and any consequent loss of power generation. In addition, the U.S. will pay to Canada \$1.875 million for each call for supplementary flood control, up to a total of four calls—or a total amount of \$7.5 million.

Determination of Downstream Power Benefits

Downstream power benefits are defined as being the difference in the hydro-electric power capable of being generated in the U.S. with and without the use of the Canadian storage. The Canadian storage is assumed to be first added to the defined existing or storage under construction of 13 m.a.f. in the U.S. Downstream power benefits are to be measured in terms of increased dependable capacity and increased average annual usable hydro-electric energy. This energy is to be made available to Canada in equal monthly amounts unless otherwise agreed by the operating entities in Canada and the United States.

There are two annexes to the Treaty dealing respectively with "Principles of Operation" and "Determination of Downstream Benefits". In the first annex are set forth the basic procedures to be followed with the objectives of providing the required flood control and power benefits. Prior to installation of generating facilities on the main stem of the Columbia River at or downstream from Mica Creek, Canadian storage will be operated to produce optimum power generation in the U.S. After power generating facilities are installed on this part of the Columbia River in Canada, Canadian storage shall be operated, subject to a limitation as to rate of change of method of operation, to produce optimum power generation in both Canada and the U.S. Modification of operating procedures may be made by mutual agreement.

Determination of the plan of operation of storage for any year is to be made annually at least five years in advance, thus assuring both Canadian and U.S. entities of a definite amount of downstream benefit power at any time during the next succeeding five years.

In the second annex (Annex B) is set forth the detailed procedures to be followed in computing downstream power benefits. This includes a definition and description of the existing U.S. base system made up of generating plants, together with their storage capacities which total 13 m.a.f. of developed storage and in which the Canadian storage will be used for power generation.

The dependable hydro-electric *capacity* to be credited to Canadian storage will be the difference between average rates of generation which can be maintained in the U.S. base system during a critical stream flow period with and without Canadian storage, divided by the estimated critical period average monthly load factor.

The increase in average usable hydro-electric *energy* is to be determined firstly by computing the difference between the available hydro-electric energy in the U.S. base system with and without Canadian storage. The entities will then agree on the part of available energy which is usable (i.e. marketable) under the two conditions. This may be a diffi-

cult assignment since the entities will be dealing with a hypothetical system in the "without" condition. They will have to consider actual and potential markets and the transmission systems needed to serve such markets. To avoid the reduction which would occur to the Canadian energy entitlement should greatly increased secondary energy markets be developed in the U.S. (as might result for instance from a large transmission capacity intertie with California), a limit is placed on the amount of secondary energy which may be regarded as usable for this purpose.

Accordingly, the part of the available energy which is to be considered usable is defined as the sum of:

(a) the firm energy,

(b) the energy which can be used for thermal power displacement in the Pacific Northwest Area, and

(c) the amount of the remaining portion of the available energy which is agreed by the entities to be usable and which shall not exceed in any event 40% of that remainder.

While for the purpose of computing downstream power benefits there is a limitation on the amount of residual secondary energy to be treated as usable (item (c)), there is no limitation on the amount of hydro energy which may be used for thermal energy replacement in the Pacific Northwest area. As a consequence, the effect of concurrently increasing thermal and hydro generation and of co-ordinating the use of these two sources of energy will be to decrease the amount of downstream power benefits arising from Canadian storage. To take the extreme case, one can visualize that if hydro and thermal capacity were sufficiently large the hydro generating plants could use the river flow virtually as it would come naturally and no regulation of flow would be needed. This extreme condition is not expected to develop, but there will be a trend towards it. This decline in downstream power benefits, however, will not commence so long as the major portion of loads in the area are met from hydro generation.

The rate at which the decline in downstream power benefits will occur will depend on the many factors influencing the feasibility and economy of both hydro and thermal generation and in the rate of load growth. Only an approximate estimate of the probable trend can be attempted. An estimate developed during the course of the Treaty discussions and which has been used to some extent for economic studies is as follows:

Year	*Dependable Capacity (Mw)*	*Energy (Average Annual Mw)*
1970	1,320	763
1985	1,125	396
2010	212	212

The disposal of Canadian downstream power benefits has been allowed for in Article VIII, Section (1) of the Treaty:

(1) "With the authorization of Canada and the United States of America evidenced by exchange of notes, portions of the downstream power benefits to which Canada is entitled may be disposed of within the United States of America. The respective general conditions and limits within which the entities may arrange initial disposals shall be set out in an exchange of notes to be made as soon as possible after the ratification date".

Delivery of Power and East-West Standby Transmission

The Treaty provides for delivery of Canada's entitlement of downstream power benefits to a point on the International boundary near Oliver, B.C. It also provides for provision by the U.S. of standby transmission service adequate to safeguard the transmission in Canada from Oliver, B.C. to Vancouver, B.C. of Canada's entitlement to downstream benefits. For this service Canada will pay to the U.S. $1.50 a year for each kilowatt of hydro-electric capacity to which it is entitled. This payment will cease when later a mutually satisfactory electrical generation and transmission co-ordination arrangement between the Canadian and U.S. entities is achieved. The provision of standby transmission could result in considerable capital saving in Canada during the earlier years of the Treaty.

Kootenay River

The U.S. may, at any time, during a period of five years from the ratification date of the treaty, commence construction of a dam on the Kootenay River near Libby, Montana. The elevation to which water may be raised by this dam is specified. This dam, if constructed, will cause flooding in the Kootenay Valley in Canada, and Canada, will at its cost, make available and prepare for flooding the area affected in Canada.

All benefits arising from the proposed Libby dam which occur in either Canada or the U.S. will accrue to the country in which they occur. The U.S. will normally operate the Libby dam to meet its own purposes in the U.S. However, if Canada considers that any change in the method of operation might be advantageous, consultation between the two operating entities of the two countries may take place, and if it would not be disadvantageous to the U.S. the operation will be varied to suit Canada.

The Treaty provides for various diversions which Canada may make at specified future times from the Kootenay to the Columbia River. The first of these would not exceed 1.5 million acre feet per annum and may be made at any date after the expiration of 20 years following ratification. Larger diversions may be made after 60 years and expiring 100 years after ratification. The objective of these limitations is to assure to the U.S. the continued economic use and value of the Libby project.

If the U.S. does not exercise its option to build Libby, Canada could, should it so desire, at any time make a major diversion from the Kootenay River to the Columbia. It should be noted, however, that such diversion would not be advantageous until after considerable generating plant has been installed on the Columbia River in Canada.

Provisions for Carrying out the Treaty

Implementation of the program under the Treaty will require the designation of operating entities in both Canada and the United States. In the case of Canada it is expected that the operating entity will be the British Columbia Hydro and Power Authority. There will also be a Permanent Engineering Board, consisting of two members appointed by Canada and two by the United States, to make periodic inspections, to require reports from the operating entities and generally to observe the operation of the plans provided for by the Treaty. The Board will report to the governments of Canada and the United States whenever there is a substantial deviation from the hydro-electric and flood control operating plans.

If the entities cannot reconcile any differences that arise between them with the help of the Permanent Engineering Board, or if there are other unresolved differences, the Treaty provides that either party to the Treaty—that is, either Canada or the United States—may refer the matter to the International Joint Commission. If the Commission does not render a decision within stipulated times, either party may submit the difference to an arbitration tribunal.

Treaty Term

The Treaty, if ratified, will remain in force for a minimum of 60 years, terminable thereafter on ten years'

notice by either party. There are, however, as previously mentioned, special provisions that extend beyond the minimum 60-year period in relation to flood control and certain diversions of water from the Kootenay River.

Achievements of the Treaty

Having briefly outlined some of the Treaty Terms, it seems appropriate now to summarize the Treaty achievements. Firstly, and perhaps most important, the Treaty assures recognition by the United States of the principle that the downstream country should share the benefits it will get from storage in the neighbouring upstream country. This has never, so far as is known, been accomplished before and is a new development in international co-operation.

The Canadian power entitlement to downstream benefit power is by no means insignificant. The following tabulation gives the estimated figures for the year 1970, after the Mica Creek storage project comes into operation.

TABLE 1

Benefit at generators

	Dependable Capacity Mw	*Av. Amount Usable Energy—Mw*
Arrow Lakes	785	484
Duncan Lake	110	75
Mica Creek	415	204
TOTALS	1,310	763

The 763 average Mw. is equivalent to about 6,700 million kw. hours per year. This is equal to about 60% of the present annual consumption of energy in Southern B.C. for public utility and industrial purposes.

In addition to this supply of power and energy the power benefits which will arise in Canada from construction and operation of Libby (if constructed) and Duncan Lake storages will, on the Kootenay River provide, with suitable co-ordination with another system, a further 224 Mw. of firm average energy.

As previously noted, the Treaty makes provision for flexibility in the plans under which the storages will be operated. As power generation facilities are installed on the Columbia River in Canada, it will be possible to devote steadily greater proportions of the stored water to increasing power generation in Canada and the United States jointly instead of in the United States alone. There will thus be a shift of emphasis in the future from shared downstream benefits to Canadian power production. While the nature and timing of Canadian power plans cannot be finally set at this date, it is expected that the Columbia River development will ultimately produce 20 billion kilowatt hours of power each year in Canada over and above the 6.7 billion kilowatt hours initial share of downstream benefits.

General Review of Economic Aspect

Numerous estimates of power cost on many different bases were made as aids to judgment in negotiating the Treaty. However, unless the basic assumptions on which these estimates were based are clearly understood, they are liable to be misleading and no useful purpose can be served by presenting such material outside of context. Factors which have to be considered include estimated capital cost of projects, the cost of capital and basis of financing, the magnitude, location and rate of growth of load, possibilities of sales in the U.S., and the co-ordination with existing and future facilities in Canada. Some of the early investment, particularly that relating to Mica Creek reservoir, will later be utilized to serve for at-site generation, and for downstream generating plants later to be constructed in Canada. Canadian entitlement to downstream benefits is expected to decrease, the expected rate of such decrease can only be estimated and is not subject to Canadian control. Due to these various uncertainties, cost estimates made at the present time must be regarded as tentative; however, they are indicative of the order of cost.

Considering firstly Arrow Lakes and Duncan Lake storages, the costs of these projects were estimated by the I.C.R.E.B. as follows:

Arrow Lakes	$66,400,000
Duncan Lake	$24,800,000
Total	$91,200,000

Capital payment by U.S. for flood control benefits in respect of these storages: $63,200,000

Estimated net capital cost for power............ $28,000,000

The estimated Canadian entitlement for these two projects is 895 Mw and 5,000 million kwh per year.

Assuming 7½% annual cost (including interest at 5½%, amortization 0.41%, based on 50 year life), annual cost would be:

Storage reservoirs: $28,000,000 at 7½% per annum	$2,100,000
U.S. standby charge for transmission to Vancouver: 895 Mw at $1.50 per kw	$1,342,500
Total annual cost	$3,442,500

The delivered energy, after allowing say 5% for transmission losses, would be 4,750 million kwh. The unit cost per kwh delivered to the Canadian border would be 0.73 mills.

Due to its later position in the storage credit sequence, higher cost per acre foot impounded, and lesser flood control benefit credit, the unit cost of downstream benefit energy resulting from Mica Creek storage will be much higher. At the present time to make even an approximation of cost is difficult. A generally accepted capital cost estimate for Mica Creek storage dam, without generating equipment, is $247 million. This, however, is for a dam to provide 11.85 million acre feet of storage, instead of seven million acre feet as required by the Treaty. The cost of downstream benefit energy computed on the same basis as the preceding estimate for Arrow Lakes and Duncan Lake and based on use of seven million acre feet of storage from such a dam would be in the order of 11 to 12 mills per kwh. However, this is an unrealistic figure because much of the cost of this project can be allocated to at-site generation.

Studies are now proceeding on the economics of the Mica Creek project to determine the extent to which the initial investment, having in mind a storage capacity for seven million acre feet, can be decreased. While undoubtedly considerable reduction in cost will be found possible, the ultimate justification of Mica Creek project will still lie in at-site generation and firming up of flow for downstream generation in Canada to a much greater extent than it does for the production of downstream benefit power in the U.S.

Notwithstanding the higher unit cost of the downstream benefit power produced in the U.S. credited to Mica, the overall average cost of all downstream benefit power is very favorable (well under 4 mills per kwh. including standby transmission facilities). The very low early costs resulting from Arrow Lakes and Duncan Lake power will be invaluable to the Columbia project in its initial years while power demand is building up, and any early surplus arising on this account will assist in providing a reserve to "cushion" the initial impact of the Mica Creek fixed charges when these are added.

It is not possible within the scope of this paper to review in detail the probable trend of costs resulting from installation of generating facilities in Canada. Preliminary studies, based on the interest and amortization rates

previously suggested indicate the probability that the average delivered cost of energy, including all the transmission costs, will be in the order of 4 mills per kwh. This figure compares very favourably with Columbia River power costs in the U.S. when account is taken of the difference between applicable interest rates of the two countries.

Some Points of Controversy

On a matter as complex as the Columbia River scheme, there inevitably are innumerable points of controversy. The Treaty, from its nature, is the outcome of controversy and must reflect compromise by the diverse interests concerned in its preparation. Much of the subsequent criticism by the public relates to aspects which could only be resolved by compromise and could not, from their nature, be settled to the complete satisfaction of either party. To deal in any way exhaustively with these divergencies of viewpoint would be much beyond the scope of this paper. It might be of interest, however, to refer in very general terms only to three points established by the Treaty, as follows:

1. Downstream power benefits are to be divided equally between Canada and the U.S.—Why are not costs divided equally?
2. More power could have been generated in Canada had the Kootenay River been diverted to the Columbia—Why, therefore, was the U.S. given an option to construct Libby dam, thus preventing any major diversion during the period of the Treaty?
3. Why was the Arrow Lakes dam flooding up to Revelstoke included, when the same storage might have been obtained with a lower dam on Arrow Lakes and a higher dam near Mica Creek?

Question No. 1 relates to what economists refer to as the "net" or the "gross" approach. Should the net product be divided equally after allowing for the cost of producing it or should the gross product be so divided? Clearly the "net" approach has an appearance of being the more equitable in relation to a co-operative partnership agreement. From the practical angle, however, in arrangements between two sovereign countries there is much to be said for the "gross" approach, if only on account of its simplicity.

In the "gross" approach each country is responsible for constructing facilities required under co-operative agreement in its own country only. It is not concerned with construction and the costs thereof in the other country. It is true that in the early stages of the Columbia development Canada will have to spend more than the U.S. to obtain an equal amount of power. This, however, is because the U.S. has already made the necessary expenditures on generating plants and developments on the Columbia River, and these plants, with very little addition in capacity, will be available to produce additional power for both countries. After considering the many aspects, including costs, the I.J.C. recommended, subject to certain safeguards, an equal division of gross benefits and the Treaty follows this recommendation.

Question No. 2. Water flowing down the Kootenay River in Canada is utilized over about 350 ft. of head. Water diverted to the Columbia could ultimately, when all projected developments are completed, be utilized over about 1,000 ft. of head upstream from the confluence of the Columbia and the Kootenay. The increased power which could be generated would amount to approximately 300 Mw. of firm energy. Cost estimates showed that this additional power and energy could be produced at less than present-day thermal generation cost in Canada, although not at a cost low enough to find a market in the U.S. It probably would be many years before this additional power could be marketed in Canada. It can also be shown that the unit cost to Canada of generating power from Libby storage is considerably lower than the unit cost to Canada of developing a larger amount of power on the Canadian reach of the Columbia. As a result the unit cost of the increment of increased power output on the Upper Columbia is relatively expensive. The U.S. urgently requires a storage reservoir on the Upper Kootenay to control floods in the Bonners Ferry area as well as to provide at-site and additional downstream power. This storage could be either at Libby or alternatively two reservoirs, one at Bull River and one at Dorr could be constructed in Canada.

The Canadian reservoirs would be less costly than Libby, but much more costly per acre foot of storage than Arrow Lakes. The cost, therefore, of downstream power received in Canada during the early years of the Treaty, would be considerably increased over what it would be with the Arrow Lakes project. Undeveloped hydro-electric power resources are comparatively plentiful in B.C., and can be developed at comparable or lower cost than the incremental cost of power arising from the proposed major diversion of Kootenay flow to the Columbia. However, the major disadvantage of the Dorr-Bull River reservoir project used for diversion is that it would also flood an undesirably large area of potentially valuable valley bottom land. The East Kootenay valley would be flooded from near the International Boundary to Canal Flats, and the Upper Columbia Valley from Canal Flats through Columbia and Windermere Lakes to Luxor. This flooding would displace over 1,600 persons and inundate 90,000 acres of land, creating a new major water barrier to East and West road and rail travel. Balancing of these and other factors led to the conclusion that, on suitable terms, the most appropriate solution to the Kootenay River problem lay in construction by the U.S., should it so desire, of Libby dam.

Question No. 3. One of the main objections to Arrow Lakes dam has been that a substantial amount, or all, of the storage to be provided at Arrow Lakes could have been provided at Mica Creek, thus saving the flooding of about 25,000 acres of land, half of which can be classed as arable, and affecting about 2,000 people. However, there are obvious and heavy disadvantages in transferring storage from Arrow Lakes to Mica as an examination of the following figures will indicate:

Drainage area above Mica	8,200 sq. miles
Average yield	20,400 c.f.s.
Drainage area between Mica and outlet of Arrow Lakes	6,200 sq. miles
Average yield	21,700 c.f.s.
Gross head to be developed between Mica full pool and outlet of Arrow Lakes, approximately	990 ft.
Gross head to be developed in Canada below Arrow Lakes (Murphy Creek Project), approx.	75 ft.*
Gross head developed or to be developed (1129 feet existing or under construction) in U.S.A. downstream of Arrow Lakes	1,201 ft.

*This might be increased by 36 feet if the Boundary project is found to be economically feasible.

In considering the problem of storage location in greater detail, there are at least three factors, as follows, which have to be weighed:

1. Construction of Mica Creek dam would take longer than Arrow Lakes dam—including two seasons for site investigations — approximately nine years as compared with five years for Arrow Lakes. Both Canada and the U.S. will require additional sources of power to be developed within five years. In the U.S. this might take the form of storage which would be developed before Columbia River storage in Canada, thus having the effect of reducing the value of such storage when constructed. In Canada it would probably necessitate development of more expensive thermal power.

2. It is important that power be made available in Canada to suit the Canadian load growth and at low cost during the early years while the load is small. Arrow Lakes has a great advantage over Mica in this respect. Its estimated cost is $66.5 million to produce 4.25 billion kwh/year downstream power benefits returnable to Canada in first-added position, compared with $247 million at Mica in first-added position to produce a Canadian entitlement to 5.25 billion kwh. It is also to be noted that Mica could not, in any event, take a "first-added" position, since Mica could not be built as quickly as U.S. storage projects.

Even the figures above do not fully reflect the advantage of Arrow Lakes since they do not take into account the $52 million to be paid for flood control benefits under the three Treaty projects. Mica could not provide a similar degree of flood control due to its position further up the drainage area, and the measure of flood control that Mica could provide would be more costly.

It is also of significance to note that even with the complete head developed, there would still be little cost differential in favor of Mica. This is shown in the following figures:

Gross head developed or being developed on Columbia River in U.S.	1,201 ft.
Allow half of this head for return of "downstream benefit" power	600 ft.
Gross head to be developed on Columbia River in Canada, downstream from Mica	
Above Revelstoke	989 ft.
Murphy	75 ft.
Total	1,064 ft.

(Additional head may be developed at Boundary, and some generating plant may be installed at Arrow Lakes.)

Estimated cost per acre ft.—Arrow Lakes

$$= \frac{\$66,500,000}{7,100,000} = \$9.3 \text{ per acre ft.}$$

Estimated cost per acre foot—Mica

$$= \frac{\$247,000,000^{*}}{11,685,000} = \$21.30 \text{ per acre ft.}$$

Cost of Arrow Lakes storage per acre foot per foot of head gained by Canada:

$$\frac{\$9.3}{600 + 75} = \$0.0137$$

Cost of Mica storage per acre foot per foot of head gained by Canada:

$$\frac{\$21.3}{600 + 1064} = \$0.0128$$

* Any estimated cost figures quoted herein are subject to review.

Ultimately, therefore, only when all head is developed would Mica storage, on a first-added basis, become comparable in value to Arrow Lakes storage and at that time much of the storage in Mica is needed for at-site and downstream generation in Canada and must be withdrawn (as per Treaty) from allocation to the United States for generation of downstream benefit power.

3. The basic objective of the Treaty is to make available storage in Canada to be used to improve flow in the U.S. However, the day will come when generating facilities to meet Canadian loads will be installed in Canada. The method of operation of storage to suit such generating plants will be quite different from that required to suit U.S. plants on the Lower Columbia River. As a result of having the storage divided into the two reservoirs, Mica and Arrow, both requirements can be met. Mica storage and its at-site generating plants, together with downstream installations in Canada, can be operated to suit the Canadian load pattern, while discharges from Arrow Lakes will be approximately such as are required for U.S. generation. If all the storage had been concentrated at Mica, generation to suit Canadian requirements would have resulted in a very substantial reduction in downstream benefit power in the U.S. or alternatively, operation to meet U.S. requirements would result in widely fluctuating flows through the Mica generating plant with a consequent major reduction in the firm output of Mica generation.

Arrow Lakes and Mica storages are complementary. Arrow Lakes will provide early low cost power returns, and later will serve to maintain the level of downstream benefit power, while Mica's function will be increasingly to regulate flow for at-site and downstream generation in Canada.

Summary and Conclusions

Although the full conclusion is yet to come and will not be apparent until after the project has been operating for some years, there is no doubt that implementation of the Treaty will be greatly beneficial to both Canada and the U.S. While the terms of the Treaty are such as to assure to both countries certain basic benefits, they provide for considerable flexibility in the working out of details and this phase, with certain checks, is left to the operating entities. The fact that this measure of flexibility exists presages well for successful co-operative utilization of the Columbia River upstream storage.

Acknowledgement

The work of A. W. Lash, M.E.I.C., Consulting Engineer and E. T. Quirk, M.E.I.C., Generation Planning Engineer, both of the British Columbia Hydro and Power Authority, in the preparation of this paper is gratefully acknowledged.

References

1. Treaty between Canada and the United States of America relating to Co-operative Development of the Water Resources of the Columbia River Basin —January 17th, 1961.
2. Statement by the Right Honourable John Diefenbaker, Prime Minister of Canada, after signing Columbia River Treaty — Washington, D.C. — January 17th, 1961.
3. Report to the International Joint Commission — United States and Canada — Water Resources of the Columbia River Basin — International Columbia River Engineering Board — 1959 — Ottawa, Ont. — Washington, D.C.
4. Report of the International Joint Commission — United States and Canada — Principles for Determining and Apportioning Benefits for Co-operative Use of Storage of Waters and Electrical Inter-Connection within the Columbia River System — Washington — December 29th, 1959.
5. Report to the Governments of the United States and Canada Relative to Co-operative Development of Water Resources of the Columbia River Basin dated September 28th, 1960 — Ottawa.
6. Analysis and Progress Report — Co-operative Development of the Columbia River Basin Water Resources — Canada and the United States dated October 19th, 1960.
7. An address by the Honourable Ray Williston, Minister of Lands and Forests for B.C. in the debate on the Speech from the Throne, B.C. Legislative Assembly — February 8th, 1961.
8. Water Resources Paper No. 124 — Surface Water Supply of Canada Pacific Drainage, British Columbia and Yukon Territory — Department of Northern Affairs and National Resources, Water Resources Branch, Ottawa, Ontario.
9. Water Powers of Canada — Water Resources Branch, Department of Northern Affairs and National Resources, Ottawa, Ontario.
10. Problems of Development of International Rivers on the Pacific Watershed of Canada and the United States — General A. G. L. McNaughton, M.E.I.C., Chairman, Canadian Section, I.J.C. Paper presented before the Fifth World Power Conference, Vienna, Austria, June 17th-23rd, 1956.
11. Review Report on Columbia River and Tributaries — Appendix A — Columbia River Basin in Canada — Corps of Engineers, Department of the United States Army, North Pacific Division, October 1st, 1948 — Portland, Oregon.

PROGRESS IN POWER DISTRIBUTION

R. E. Jones, Contributing Editor, Electrical News and Engineering

THESE REMARKS are applicable mainly to North America.

The distribution of electric power really got its start in 1882 when Edison commenced his direct current system in New York. It supplied 225 houses with a total of 5000 lamps. Four years earlier series arc systems were in use to light streets and a few buildings. Streets were already obscured by many-armed poles of telephone, telegraph, messenger, fire alarm and ticker circuits, many of which were allowed to remain after the owners were defunct.

Edison chose 110 volts, probably because it was the most satisfactory for the carbon filament lamp he had invented. Two dynamos were connected in series so as to have 110 volts for the lamps and 220 volts for the lower loss transmission, a system widely used to this day on low voltage single phase circuits. Today only a few direct current systems remain in the downtown areas of large cities.

The Edison system was underground and used 20 ft. lengths of iron pipe, inserted in which were three solid copper conductors, each bound with a heavy layer of yarn. The pipes were placed on end and filled with compound. The pipes were placed in the ground and joined with split egg-shaped castings which had provision for service take-offs. At each street intersection there was a fuse box, with the top flush with the pavement, into which both mains and feeders were connected. There is probably little of this system in use today.

Also in 1882 was invented the transformer by Gaulard and Gibbs. It was brought to America by George Westinghouse who redesigned it for production on a commercial basis and used it on his initial trial at 500 to 100 volts in Massachusetts in 1886. The same year a commercial installation went into service at Buffalo, New York, in spite of some effort on the part of the public to limit lines to 800 volts. Primary voltage was 1000 and secondary was 100 volts at 133 cycles. In 1888 Tesla designed the polyphase system. In 1890, 60 cycles was selected for general use and 30 cycles for conversion to direct current.

As alternating current voltages increased with distances supplied a branch of distribution became important—transmission—which is actually distribution over long distances of relatively large blocks of power. The characteristics of transmission lines are the higher voltages necessary and the large amounts of power carried, requiring mainly mechanical differences from the low voltage circuits.

Voltages

In Italy in 1886 power was transmitted 17 miles at 2000 volts. In England we know of 10 kv. in the early 90's. Buffalo received power from Niagara Falls in 1896. Ten years later 60 kv. was in operation in Ontario and a few years later 110 kv. In 1930 Ontario had 220 kv. and in 1936, 287 kv. was used to deliver power from Hoover Dam. Lines are now built up to 500 kv. and an experimental installation at 750 kv. is under construction.

At the other end of the scale, over the years the original 100 to 110 volts has increased to 120 by increments of five volts. For mixed power and light 120/208 volts wye is in common use; in Europe it is 240/416 volts. In U.S.A. 440 to 480 volts is standard for motors and as a result a 277/480 volt system is receiving wide publicity there. In Canada where the larger motors are predominately 550 or 600 volts the die seems to be cast for 240/480 volts single phase, with 240/416 volts for combined power and lighting when the conditions warrant the expensive switch to another voltage.

Primary voltages soon climbed to 2080 and 2200. This latter, boosted gradually to 2400 volts, has been in common use for 50 years. In 1910 the 4000/2300 volts wye system with common neutral was devised in Toronto by Hood. Most 2400 volt delta systems have now been converted to the wye connection which allows of the use of the existing transformers. In 1928, 8.32/4.8 kv. was started in Ontario. In 1935 a general start was made on 12.5/7.2 kv. wye. There are other voltages in this latter range but they are not too common. Some years ago there was a doubling of voltage to 25/14.4 kv. wye. This has been highly satisfactory with a large reduction in losses at small cost. A couple of operators in U.S.A. are trying out 34.5 kv. wye. The cost of transformers at this latter voltage is high and its use will be somewhat limited for the present.

In the early days of electric distribution someone made a "rule of thumb" that to transmit power economically it was necessary to use "1000 volts per mile". It is remarkable how applicable this rule has proved even today. That person either had extraordinary powers of perception or was just plain lucky.

Substations

For many years direct and alternating current feeders reached out from the generating station. As both loads and distances grew it was necessary to use higher voltage to a substation the lower primary voltage thence.

At first a typical red brick building was used to house the transformers and high and low voltage equipment, the incoming and outgoing feeders using porcelain bushings set into the wall. When transformers were designed to withstand weather the high voltage equipment began to move outdoors until now transformers are seldom enclosed. There are now two schools of thought as to whether to house indoor equipment or to use metal-clad or other type of outdoor apparatus without a building. And so with transformers there is difference of opinion, some preferring three-phase units on account of space and cost; others use single-phase units where space permits due to ease of handling in emergency and ability to operate at reduced capacity with two transformers in event of a winding failure.

Structures are of wood, steel, aluminum and in Mexico, of concrete. If structure and bus bars are both of aluminum the latter must be clearly marked such as with reflecting tape.

One problem in residential areas is the loud hum from transformers. Various methods of eliminating this nuisance are surrounding the transformers with a ceramic wall, rubber mounting discs for the transformers, surrounding earth banks and a source of neutraliz-

ing noise. Stations among new homes have been disguised as houses with the exception of the transformers walled in to the rear.

Supports

All but the circuits of 100 kv. and up are generally supported on poles of wood, steel or concrete. The latter two have not found general favor except for urban locations under certain conditions. For use elsewhere there is the question of cost, the lack of insulation to ground, the necessity of a ladder to reach the conductors and, except in the case of large diameter hollow poles, the need of some concrete for the setting in soil.

From the earliest days of the telegraph wood has been used for the support of overhead wires. For many years cedar was the standard material in Canada, Eastern cedar in the East and Western red cedar in the West and for longer poles anywhere. In the United States, chestnut was much used until the species was almost wiped out by a blight. In recent years due to depletion of the supply of Eastern cedar, pine has been the large source of poles up to 40 ft., jack pine in Canada and southern pine in the U.S. Other species have been used to a limited extent.

While eastern cedar would last up to 40 years under favorable conditions life expectancy was rated at 20 years, while the western cedar might fail in five or six years in certain soils.

The practice now is to treat all poles with a preservative. Western cedar may have only a dip treatment of the incised butt or it may be full length. The pines are given a full length pressure treatment. Preservative was almost entirely creosote for nearly 100 years but in recent years it has had stiff competition from pentachlorophenol in fuel oil. The penta gives a cleaner pole without loss in toxicity. The life of treated poles should average 35 years.

In the early days the poles were erected with a hope that a storm would not break them. Then a formula was evolved and poles were selected according to the anticipated simultaneous transverse loading of the poles and conductors, in most of Canada calculated at one half inch radial covering of ice and eight pounds of wind (57 m.p.h.) on the projected area. In the 1930's research proved that while either of the above loading factors could be exceeded it was exceptionally rare that the extreme ice and wind coincided. Subsequently storm loading requirements in heavy loading areas were reduced to half inch of ice and four pounds of wind. This permitted use of lighter poles or conversely the construction of economical longer spans with available poles.

In the early days the spacing of poles was about 100 feet, perhaps because this suited the supporting of street-car trolley wires. Forty years ago there was a departure from the short spans in open country, the economical point for primary lines being 300 to 400 ft. under normal conditions. With a span of greater length costly longer poles are required.

For lines of 100 kv. plus the standard practice is to use twin poles with long arms or towers and spans up to 1000 ft. The latter may be in several forms — "A" frames, small base, three legged, four legged or single base towers, the latter being guyed in all directions. Steel has been the standard material for towers but recently some utilities have used aluminum, the light weight being a big advantage in remote areas. In fact some towers of aluminum are being transported assembled and then placed in position by helicopter.

In the last 25 years two old inherited practices have disappeared— vee roofing of pole tops with the erroneous idea that rain would wash off the angle surface instead of sinking into the coarse grain of the wood; and the cutting of a gain to seat the cross-arm, nominally five eighths of an inch deep, with a wide variation according to the whim of the lineman with a resulting loss of much of the needed sapwood.

The crossarm is still largely fir, although the vast amount of this material used for plywood is depleting the supply. Perhaps western hemlock will be the next wood in Canada for crossarms. In U.S., treated southern yellow pine is in large use, where much of the fir arms also are treated.

We have been and continue to be wasteful of crossarm material, using many more and often larger arms than are necessary. This also far from improves the appearance of our streets.

The pins in the crossarm are of wood or steel, the wood pin having changed little in 100 years. Wood used is practically all black locust.

A large proportion of the utilities are now going to steel pins, particularly for the higher voltages. In spite of a much higher cost the steel pin is proving economical due to its continued strength, long life and absence of acid digestion of wood. While the half-inch shank pin appeared to have sufficient initial strength, continued pressure from wind on the conductor caused gradual bending and a five-eighth inch shank is now the general standard for low voltage lines.

With the common neutral wye primary system, a single phase circuit may use a steel top-pin instead of an unsightly arm.

Guying of points of unbalanced load has changed little except that generally the 5 ft. log "dead-man" has been replaced by a metal plate of any of a number of designs. Now the anchor is placed at the calculated correct distance from the pole rather than at what the lineman considered to be a suitable spot.

The early bottle-glass telegraph pin insulator with a larger groove was the standard for many years for low voltage lines but 50 years ago wet-process porcelain came to the fore with the advantage that it would not break easily, such as in a man's hand when screwed on too tight. Then tempered glass became available and is now used to a considerable extent.

The early method was to dead-end a conductor on two pins of double arms with a figure-eight tie with the mistaken belief that the two pins shared the load, resulting in many early pin failures. Then a guy-strain insulator was used for many years, followed by a spool insulator in a clevis. At much over 5 kv. radio interference became a problem no matter how large a spool was used. The standard dead-ends now are suspension type insulators for all voltages.

For high voltage lines, usually those over 60 kv., strings of 10 in. suspension disc insulators are installed. As the voltage increased it was necessary to use larger diameter conductors to reduce corona losses. When much over 300 kv. is used another arrangement became necessary — bundled conductors. Two or four parallel conductors are attached to the one insulator clamp at a spacing of perhaps 10 in., using mid-span spacers.

Secondary conductors are still sometimes supported on crossarms but the general practice is to use vertical insulator racks.

Conductors

While the steel wire used for telegraphs and telephones had sufficient strength it lacked the conductivity necessary for power use. An available and cheap material was copper, with a low resistance and excellent weathering characteristics. When additional strength was required "hard drawn" wire was obtained by omitting the usual softening after the final draws through the dies. For flexibility in handling larger sizes are stranded.

In 1895 in both France and California lines with short spans were built with solid aluminum wires. In 1899, a seven-strand aluminum conductor was used in U.S.A. and in 1902, a 50 kv. seven-strand aluminum

line was erected from Shawinigan Falls to Montreal. In 1908 steel-reinforced aluminum conductor was designed and the next year a 33 kv. line of No. 2 ACSR was erected in Ohio. In the smaller sizes usually six strands of aluminum are spun around a galvanized core of very high strength steel. For large conductors there may be two layers of aluminum strands with a stranded steel core. Various combinations of aluminum and steel have been used for special conditions. Solid aluminum has been used for light loads.

Since 1821, efforts have been made to apply a coating of copper to steel wire, heavier than could be done by electro-plating. Various methods over the years were wrapping a copper tape and tinning, rolling on a copper shell, drawing on a copper sheath. In 1915, copperweld was born by pouring molten copper around a 48 in. by 6 in. hot steel billet in an 8 in. diameter mold and then rolling and drawing down the bimetallic material to the required size, the steel remaining centered in the conductor. To obtain greater conductivity two copper wires are stranded with one of copperweld to form copperweld-copper.

The tying of a conductor to the insulator is of the utmost importance if damage from vibration caused by the wind is to be avoided. Aluminum is particularly vulnerable to this affliction. However, this hazard has been almost universally avoided by the use of armor tape and a long tie which avoids a sharp radius of bending or by armor rods.

Where covered conductors were required, a cotton braid was applied in two or three layers and then impregnated with asphalt. This constituted an insulation for a year or so and after that formed only a mechanical separation. When it finally rotted it hung in untidy strands. Polyvinylchloride was the next covering and served well except when pulling around a glass or porcelain insulator under tension where it tended to stick and gather the covering along the wire. Now the generally used covering is polyethylene which also has high insulating value but softens under high temperature due to its 105 degree C. soft point. Weatherproof covering of conductors has been generally limited to 5000 volts and less, due to radio interference at insulator ties at higher voltages. This may not apply to polyethylene with its high insulating value. Polyethylene must be mixed with a dark pigment to avoid early cracking from sunlight.

Aerial cables have been used in some form for a couple of generations. At first, underground cables were suspended on messengers. Then there was a self-supporting single conductor cable, with a grounded outer metallic covering for neutral, for use in short spans. The next step was a single or three conductor cable, consisting of rubber insulated conductors bound in the factory to a high strength messenger with a copper tape. Later the practice of the telephone utilities was followed whereby the messenger was erected first and then the conductors were bound on with a "spinner".

Recently a new type with considerably lower cost has become available —spacer aerial cable. Insulated conductors are separated a few inches by plastic hangers attached to the messenger at the pole and in the span.

For secondaries the conductors are factory assembled to the messenger which also acts as the neutral. Some feel that with heavy loads the reduced ventilation will cause thermal problems, or at least reduce the permissible load. Others are afraid of failure due to close contact with thin insulation, a mere crack allowing a damaging leakage current.

The use of aerial cables is spreading on account of appearance, reduction of necessary tree trimming and ability to use it in places where there is lack of clearance for open wires.

Transformers

From the time of its inception the transformer has been improved in spurts, often years elapsing between changes in design.

Over the years the core losses have been reduced and the core has become more efficient by the use of better steel, notably the oriented grain type.

Some time in the 1920's, steel cases came into general use for distribution transformers. Previously the cases of cast iron were heavy and bulky, but the metal seemed to sweat oil, and one with any signs of rust was a rare sight. With the sheet metal tank, there is the problem of a protective finish. Galvanizing is too costly, and paint is often scratched during erection. On one large job the cases were coated with a good quality of paint after erection and 15 years later the finish was dull but unbroken.

Until recent years transformers were attached to the crossarms with heavy strap iron hangers. The tendency now is to attach the case directly to the pole with two bolts, eliminating the necessity of crossarms.

For some unknown reason on this continent it has been standard practice to place the high-voltage bushings at the sides near the crossarm with the secondaries in front of the case. Now a large proportion of transformers of 7.2 kv. and higher have the primary bushings in the top cover, an arrangement convenient for tapping to the high-voltage conductor above.

It has been traditional to equip distribution transformers with three reduced-voltage taps on the primary winding. Some operators still demand these taps with the excuse that low-voltage conditions require them, while the actual problem is generally low-voltage at time of heavy load, a condition that cannot be cured by fixed taps. An economical substitute for taps is an auto-transformer to be placed on the pole and connected to the secondary where required. Transformers without taps cost less and are stronger electrically.

Transformers with dual primary windings are available for use where it is anticipated that the primary voltage of the system will be changed within a reasonable period.

Manufacturers have been able to reduce costs by machine winding of the core around the coils instead of the reverse procedure. Higher basic impulse levels of insulation have considerably improved the life expectancy.

Lightning Protection

Lightning, long a hazard to all overhead wire-using utilities, has been given a lot of study coupled with laboratory research.

The simple telegraph gap drained off the lightning charge but for power use there was nothing to stop the power current following the arc created by the lightning discharge.

Early it was realized that there must be a gap, or series of gaps, set at higher than line voltage, so that equipment acting as a valve would not be submitted continuously to line potential. This was evidenced by the trouble with enclosed gaps, which became shorted when moisture crept in.

Various schemes were tried — gaps shunted with resistors; one had a mechanical breaker with a solenoid; others used various materials which allowed the passage of the surge current, but not the following power current. Such materials are a ceramic material like a building brick, coated pellets, coarse carborundum powder. Another valve device operates by drawing a thin arc between two closely spaced deionizing fibre walls.

For higher voltages, an early arrester was the electrolytic having concentric cones of aluminum, separated by a liquid which formed a film and required daily charging. Fiber discharge tubes are also used, suspended from the conductors. Sky wires are another method of protecting high voltage lines, but there is not complete agreement on their use.

What, and where, to ground has been an open question for a long time. The general idea now, is to connect all non current-carrying conducting material together and to a good ground. However, some still prefer not to have the cases of pole-type transformers grounded. There is something to be said for each method, but it would seem better to have equipment at known ground potential, rather than at an assumed zero potential to adjacent conductors and to nearby grounded objects.

Fuses and Switching

A simple blade switch does not permit opening a primary circuit under load, its use is generally limited to disconnecting without load, often in conjunction with a load breaking device. For higher voltages, there are oil, air break and air blast breakers.

For primary voltages, there has been a continuous development of devices for fusing and disconnecting. A porcelain plug in a porcelain receptacle in an iron box was soon replaced by the all-porcelain plug cutout, a favorite for nearly thirty years. Next came the box cutouts of wood and then porcelain containing a fuse tube of fiber or similar material and usually attached to the door. With heavier currents, the circuit was opened by a fuse melting in a sealed tube of carbon tetrachloride. Another has the fuse immersed in oil. Bayonet types of cutouts have the fuse-holder attached to a porcelain handle and the holder is inserted in a porcelain body. For higher voltages, there are the open-type cutouts, a switch with the fuse-holder as the switch-blade.

A common method of opening primary circuits under load, is to sever the fuse link in the tube, by application of a heavy strain on the end of the link.

An improvement in both open and closed types of cutouts, is the use of the fuse-link to hold the cartridge in position. Failure of the fuse allows the hinged cartridge to drop down, removing the tube from the circuit, without possibility of tracking and also giving a visual indication of the operation. This device was used on high-voltage in a station about 1902, but did not come into general use until over 25 years later.

A great time and travel saver is the automatic oil recloser, which opens and recloses automatically three times before locking out, to clear the many transient faults that occur on a line.

Underground

Even before the days of electric power, there was a public clamor to place the multitude of telephone and telegraph wires underground, and Edison started off on this basis. However, except in business areas where customers are close together and the load demand is high, underground distribution is considerably higher in cost than equivalent overhead construction. Recently, the head of a large electric utility estimated, that if all the electric distribution in a suburban municipality, were placed underground, it would cost each customer $5 or $6 more each month.

In 1872, a wire with paper wrapping was used for domestic bell systems, but it was not patented until 1884. The telephone people made early use of helically-wound impregnated-paper insulation with an extruded lead covering. Rubber has been on a sound basis since 1880.

In 1882, Edison installed his buried system described earlier.

1890 saw the installation of a 10 kv. cable by Ferranti in London. At first, the concentric cable had a wide paper and oil wrapping with a lead-covering in 20 ft. length. As it was too stiff, a narrow paper was used and the cable was still in operation 43 years later.

In 1895, a 13 kv. paper-insulated cable was installed, and in 1897 Buffalo had an 11 kv. rubber cable. 1900 was the year when 25 kv. rubber and paper cables were installed in St. Paul and Minneapolis. In 1902, varnished cambric entered the picture to a limited extent. For low-voltage cables, where heat is a problem, insulations of asbestos or glass-fiber have been used.

As voltages rose in the 1920's, low-pressure oil-filled cables, with paper insulation and hollow cores and reservoirs, were placed in service. In 1932, cables with 200 lb. pressure were installed in welded steel pipes with fillings of nitrogen in England and oil in U.S. Now, both types are used in America. Voltages now exceed 300 kv. and there appears to be no ceiling.

Until recent years, cable sheaths were of extruded lead, but now alternatives of aluminum and plastic are available.

While European practice is to bury armored cables directly in the earth, there were so many failures of earlier cables, that a prejudice against direct burial, has persisted here to this day. Also, perhaps, in a growing country like ours, there are more changes to streets and buildings, with consequent disturbance of buried utilities. The draw-in system is the standard for business areas of North America.

In Europe, many methods were tried: open wires on insulators in a covered trench; troughs of wood or tile containing the cables covered with asphalt; ducts of bituminous material, the walls of which collapsed and wooden "pump logs" which were a fire hazard. In Paris, the sewers were used for cables, and the services were taken up the building sewer pipes.

In 1889, a conduit company was formed in New York. Single clay-ducts were built in 1891, followed by wood-fiber pipes in 1893 and multiple clay-ducts in 1895. Later, ducts were made of asbestos.

Cable ducts have been constructed by other methods than with some form of permanent pipe. One method was to pack stiff concrete around a machine form, which was inched forward at frequent intervals, compressing the mix and leaving a continuous monolithic structure with pipe-like holes. In another system, concrete was poured around a heavy rubber hose filled with water under pressure. When the concrete had set, the pressure was released and the contracted hose withdrawn.

In Montreal, most of the wire-using utilities have rented space in a city-owned duct system.

On heavily loaded duct lines, the thermal conductivity of the surrounding soil is often a load limiting factor. In times of extra heavy loads, flooding the ducts with water has increased the safe capacity of the cables.

Memphis, in 1907, installed the first underground low-voltage A.C. network, but it was not until 1921 that the low voltage network protector was brought out. While most network transformers and equipment are installed in large costly underground vaults, Detroit has 90% of its 600 installations on poles in rear alleys.

In recent years, there has been a great deal of interest in underground distribution in residential areas. This is not a new idea as it was used to a considerable extent with the old Edison tube system and Ontario Hydro installed some 150 miles of buried primary distribution in rural areas in 1922-23. Subdividers consider it an attractive selling point to have all the poles off the street, forgetting that street lighting poles must remain and that most of the homes will later have unsightly television aerials. Many lose interest when they find that they have to pay the difference in cost between overhead and underground, the latter usually running two to three times the cost of the former.

Cables are generally directly buried, although some use plastic water pipe for protection. Transformers are now generally installed in metal kiosks on concrete pads. There is a choice of running services directly from the transformer or using a

secondary bus and pedestals. The direct feed allows for future load increases, without possibility of having to change buried conductors.

Voltage Regulation

Over 50 years ago, the necessity of regulating the voltage of a feeder at a distant point was realized.

For A.C., the automatic induction feeder regulator was designed for use in substations. The control mechanism was adjusted to maintain a constant voltage, at a distant point, the voltage at the source varying automatically according to the load. Some years later, this equipment became available for use on poles. Then, the automatic step regulator was sold for pole use, for both single and three phase circuits. In many cases a regulator is economical only as a temporary measure; it makes up for the lost voltage, but, lost power must be paid for, the correct procedure usually being to increase the conductor size, or to use a higher primary voltage.

Shunt capacitors are now in common use, particularly in areas of industrial loads. Some are connected on the whole time, while others are switched according to time or to load.

Metering

As soon as electric power was sold, there had to be a way of measuring the service. At first, there were flat rates such as $1 per year, for each 16 candlepower lamp.

Until some 25 years ago, meters were all indoors or in a weatherproof box. The case was of thin metal or glass. While the latter was the stronger of the two, it appeared to be fragile, and consequently more care was taken to avoid damaging it by both installers and customers. For some years, the majority of new homes have had outdoor meters, usually with a plug-in base, the wiring code having been amended to permit the main service switch on the load side of the meter. Advantages are prevention of theft and ease of meter reading, an important factor, now that so many housewives are away working in the daytime.

Street Lighting

Early street lighting systems fed open carbon-arc lamps on a direct current series circuit of perhaps 2000 volts. A man visited each lamp daily and replaced the carbons, an early installation being made by Brush in Cleveland in 1876. The D.C. series circuits continued into the 1920's, the open arc having been replaced by the enclosed magnetite arc. There are many A.C. series circuits today in the U.S., but in Canada, they are fast disappearing. Series circuits have been used with 4, 6.6, 7.5, 9.2 and 20 amperes. Some of the first ones were 9.2 amperes, but now 6.6 seems to be the standard, with a change to 20 amperes at the pole for each large incandescent lamp.

About 1900, the incandescent series lamp was used, and 10 years later, the multiple for street lighting. In the late 1930's, sodium-vapour lighting was introduced, with mercury available for intersections. A few years later, mercury-vapor luminaires, with directional control of light output, became popular, followed some time later by fluorescent.

Both incandescent and mercury-vapor lighting gives considerable glare. Fluorescent has a low intrinsic brilliancy with resulting ease on the eyes but the luminaire is bulky.

Series circuits were generally controlled from the station. Multiple lighting is usually fed from existing house lighting secondaries through relays. The latter were first controlled by a simple clock switch, then by an electrically wound clock with an astronomical dial, whereby the time of operation was automatically controlled according to the season. Next was the photo-electric cell controlling the turning on of the lights, according to the amount of daylight remaining. Now in some cases, the relays and control wires have been eliminated, by installing an individual cell on top of each luminaire. Relays are controlled by a pilot wire, which is alive at night or in the daytime, the latter merely allowing the lights to come on in the daytime in the event of a failure of the control.

Accident Prevention

Perhaps the greatest progress in the electric power industry, despite its tremendous growth, is the continued improvement in the accident record.

We have rubber gloves, rubber sleeves, rubber covers for energized conductors, hard hats, stick operation, aerial ladders, bucket trucks and training, the latter the most important and the spot where more progress must be made. A piece of metal or other material, can easily be made to conform to a desired pattern, but not so a human being. He must be constantly trained and retrained. Alertness is essential, as a moment of day-dreaming can be fatal; an energied conductor looks so innocent and harmless.

Prognostications

If one describes the past, surely it is his privilege, to also delve into the future. Let us look forward to 1986.

Poles will be neater in appearance, with few crossarms, the single primary conductor being on top pin, with neutral below. Three-phase circuits will be in aerial cable, probably the spacer type. For the most part, the poles will be placed in the rear of the buildings, with separate steel or concrete standards for street lighting. The power poles will be mostly of wood, with full length preservative.

Secondary bus on the poles will largely disappear, if even half the load, optimistically predicted by sales people, materializes. Any secondary bus will consist of a spacer cable, with the conductors separated.

In many places, there will be a transformer on each pole, starting with one on each third pole or an encapsulated transformer on the premises of each customer using electric space heating entirely. This latter will be in spite of the diversity factor present with secondary bus. If external, the fuse and arrester will be attached to the transformer case bolted directly to the pole.

Primary voltages will be higher, probably in the 25/14.4 kv. class.

With the increasing use of 240 volts for major appliances, and dual voltage ratings for minor ones, many services will have been converted to 240/480 volts, single-phase, or in the case of a network 240/416 volts.

In areas where a few homes have a heavy load, and others only light, a 240 volt booster wire will run from an extra transformer, so that 240/480 or 120/240 volts may be obtained as required. This would be a temporary measure and the 480 volt system would have 360 volts to ground.

The use of underground distribution will increase in business areas and for feeders to an area. More cable will be directly buried. Many network transformers will be overhead.

In residential areas, there will be a lot of buried distribution where the customer is willing to pay the extra cost, or a way is devised for painlessly raising the extra money.

Perhaps the automatic reading of meters will be in use, if the present estimates of the cost are realistic.

Streets will be better lighted, using individual photo-electric controls. Luminaires may be fluorescent, particularly if the manufacturer can make a rectangular or round light source, instead of the present long tube. Perhaps the cube could be bent back and forth to form a grid or the tube shortened and flattened to spread the light sideways in the luminaire. Such an arrangement would eliminate the present objection, on account of the bulk, also, it would be easier to control the light output. EIC

POWER IN CANADA

Design Concepts of the Brazeau Development Including River and Hydrology Studies

J. L. Reid, M.E.I.C.,
Water Resources Branch, Province of Alberta

K. G. Brittain, M.E.I.C.,
Montreal Engineering Company Limited

THE BRAZEAU RIVER, one of the largest tributaries of the North Saskatchewan River, rises on the eastern slopes of the Rocky Mountains. In common with the other rivers of the eastern slopes it has a relatively high run-off in summer, arising from glacier and snow melt, and a low run-off during the winter. As a result, a high degree of storage regulation is required to produce a dependable run-off throughout the year. For this reason, almost all hydro power production in Alberta has been confined to the Bow River where large volumes of low-cost storage could be developed on the natural lakes at the headwaters.

In the years following the Second World War the industrial growth of Alberta created a high demand for water supply and power. In the early 1950s, in anticipation of a continued growth, the water resources section of the Provincial Government and Calgary Power Ltd. initiated joint investigations of the upper reach of the North Saskatchewan River to determine the storage and power prospects. Development of storage on the river would serve the twofold purpose of alleviating the low winter flow conditions which would become more troublesome with industrial growth at downstream points, and of developing a natural resource for the production of hydro-electric power.

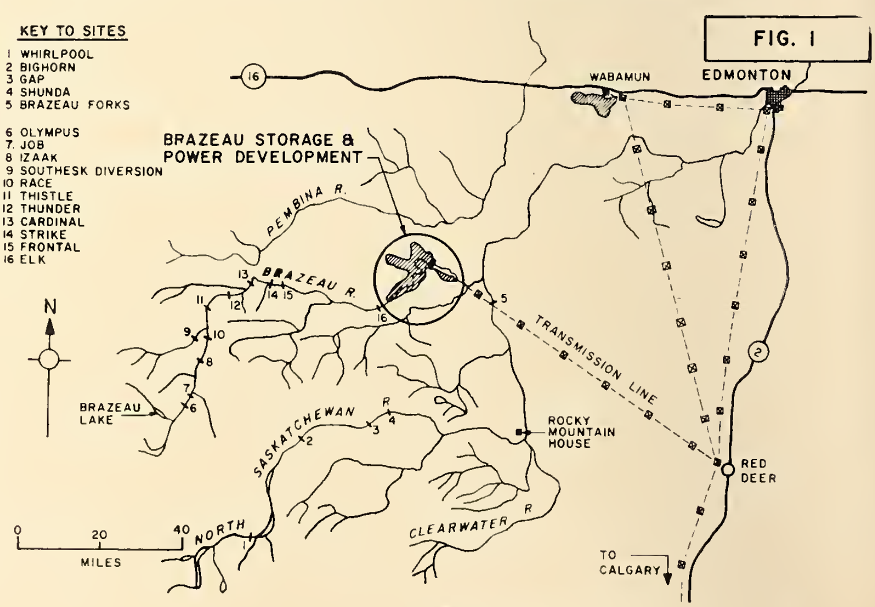
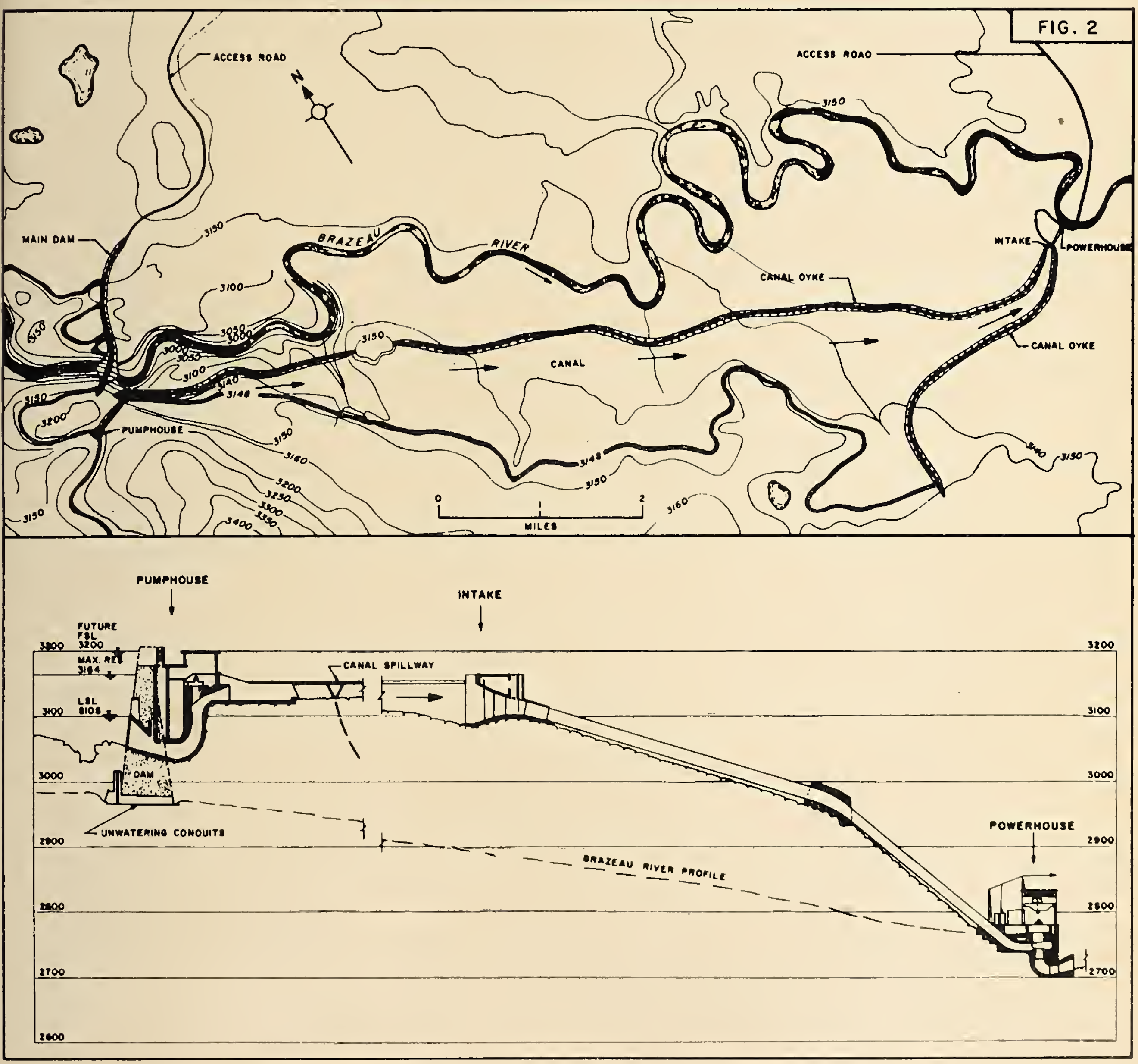


FIG. 1

The field reconnaissance investigations indicated five sites that were worthy of more detailed study. These are shown at sites one to five on Fig. 1. The preliminary field and geology reports indicated that the Bighorn site was the most attractive for storage and power development and a comprehensive investigation was carried out here, including mapping, drilling and materials testing. Unfortunately, immediate development was postponed due to the discovery of a deep gorge in the river section infilled with gravel. The Bighorn site has not been abandoned in future plans, however, and may be built at a later date. Similar unfavorable foundation conditions were found at Whirlpool and Gap sites. These adverse findings in turn removed the Shunda and the Ramparts sites from immediate consideration since they are both dependent on upstream storage.

After failing to locate a storage site on the North Saskatchewan for early construction, attention was turned to other rivers, including the Brazeau. The Brazeau had been investigated for power as early as 1913; the plan being to provide storage at Brazeau Lake and at a site about four miles above Job Creek (Olympus, Fig. 1), on the head waters of the river. A power site was suggested near the Thunder Site (Fig. 1) which could be ultimately developed for 5 to 10,000 kva. generators. Power from this development was to be transmitted to Edmonton and Calgary, a distance of some 260 miles. This was an ambitious scheme for that time as power transmission over long distances was not common. However, subsequent investigations in 1914 revealed a substantial underflow at the outlet of Brazeau Lake precluding its use for storage and the project was abandoned[1]. No further serious power investigations were initiated until the early 1950s, when a promising storage site was located at the Big Bend of the Brazeau some 30 miles upstream from its confluence with the North Saskatchewan. The investigation also disclosed an interesting prospect for

Fig. 2. Plan and Profile of the Brazeau Storage and Power Development.



a power development involving a 10 mile power canal to utilize an additional 240 ft. of head as shown in general outline on Fig. 2.

Early in 1957, Calgary Power Ltd. undertook an extensive mapping and drilling program to permit a more accurate appraisal of the combined development of storage and power at the Big Bend site. This appraisal revealed that the initial capital cost would be so high as to require deferment of the scheme for some 10 to 15 years in the logical program of the Company's expansion. In the meantime the Company's requirements could be met more economically by developing smaller increments of hydro capacity on the Bow River for peaking in combination with expansion of its base load thermal plant. On learning of this situation the Province of Alberta appointed a Committee to study the Brazeau scheme, and as a result of their findings the Province and the Company entered into an agreement for co-operative development of storage on the Brazeau River. So that stored water be made available with all reasonable dispatch for improvement of winter streamflow on the North Saskatchewan, the Province undertook, at its expense, to proceed with the immediate construction of the initial storage development on the Brazeau; while the Company, for its part, undertook to pay for the storage structures as it was able to absorb them into its system.

The Brazeau Agreement Between the Province and Calgary Power Ltd.[2]

Under the terms of the Brazeau Agreement the Province will pay the cost of the storage project if it is $14,546,000 or less but, if the project cost exceeds this amount, the excess cost is to be paid by the power Company. Repayment of this expenditure is to be made to the Province by the power Company either (i) after the Company has completed the installation of aggregate generating capacity in the Big Bend Power Development of 550,000 kw., or (ii) on the first day of October, 1980. Until repayment has been made, the Power Company pays a yearly rental for the initial storage development determined by clauses in the agreement.

The main dam was constructed in 1961 and 135,000 acre feet of water was impounded following closure on October 1 and released during the winter of 1961-1962. The conduit gates were opened on November 22 and between this time and mid-March the combined release of storage and natural flow to the North Saskatchewan averaged more than 1,000 c.f.s. In subsequent winters 300,000 acre feet will be available, increasing the winter flow in the North Saskatchewan by over 1,200 c.f.s. Provision has been made in the construction of the dam for an ultimate extension to 930,000 acre feet of storage capacity. A diagram representing the storage operation after completion of the initial stage of the dam is shown in Fig. 3.

In the meantime, the Company is proceeding with construction of the power phase of the project, which is known as the Big Bend Power Development. As shown on Fig. 2 water will be released from the reservoir through pump turbines and conveyed through a canal (perhaps more accurately described as an artificial lake) to the powerhouse some 10 miles downstream. From the canal, steel penstocks lead the water to the hydraulic turbines which operate under a gross head of 390 ft. One unit of 150,000 kw. is to be installed initially, with provision being made for four or more similar units.

The Calgary Power Ltd. System

The Big Bend Power Development will form part of the Calgary Power Ltd. generation system, which at present supplies about two-thirds of the power produced in Alberta. The installed capacity of the system is 489 Mw. of which 320 Mw. is produced by 11 hydro plants on the Bow River and its tributaries.

Because of the low fuel cost, power from the steam plants is used in the base load with the Bow River hydro energy up-graded to take the peaks.[3] Relatively little energy is required to support the hydro capacity used in the peak; and, in fact, with the continued attenuation of the peak accompanying system growth a given amount of energy will support an even larger capacity as time passes. Within the past 10 years 134 Mw of inexpensive peaking capacity have been installed in extensions to five of the existing Bow River plants to facilitate this type of loading. At one plant the annual plant factor is now only 16%, and it seems probable that plants operating at annual plant factors of only 5% or 10% may be developed where site conditions are favorable.

The Big Bend Power Development has a head of 390 ft. and requires short penstocks between the canal and powerhouse only, so that it is admirably suited for the installation of additional peaking units. The estimated cost of installing added units at the site is about $60 per kw. compared with the cost of coal fired steam capacity at about $125 per kw. The maximum system peak requirements occur in the cold winter months when the natural stream flow is the lowest. Brazeau must, therefore, have a large storage reservoir and the combined cost of storage and capacity to meet a given portion of the load demand must be less than that of an equivalent supply from other sources. To meet its ultimate peak function the total storage proposed for Brazeau will be about 80% of the total average annual run-off, thus enabling most of the power from the site to be produced in the winter months. Use of the Brazeau storage energy in the system peak is illustrated in Fig. 4 for a typical winter week.

It is estimated that the initial storage at Brazeau is sufficient for three or four units of 150 Mw. each. When additional storage is required it may be provided either at the Brazeau Storage Development or at sites upstream.

Upstream Sites

In 1960 extensive mapping of the upper Brazeau River was prepared from aerial photographs. Ten prospective sites have been investigated and are shown on the map of Fig. 1

Fig. 3. Diagram showing reservoir elevations during construction and first year of power operation.

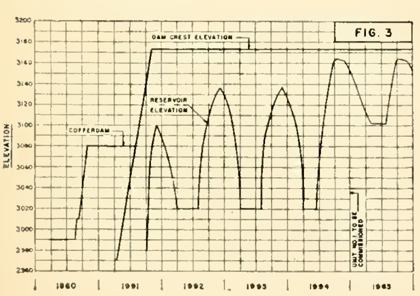
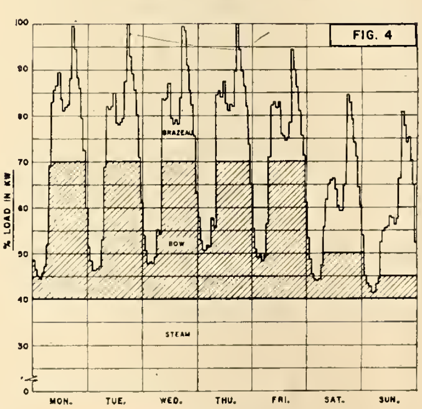


Fig. 4. Typical weekly load curve.



and the river profile of Fig. 5. The total fall of the river from the Olympus Site to the Brazeau Reservoir is 2510 ft. The preliminary investigations indicate that about 2100 ft. of the total is feasible for development. The two upstream sites, Olympus and Izaak, are primarily storage sites where a total of 510,000 acre feet of water could be stored for release during the winter season. In addition, 75,000 acre feet could be stored at the intermediate power sites. These investigations have ascertained that 1500 million kwh. would be available annually from the Brazeau River System when fully developed. The ultimate installed capacity for the river is estimated to be four million hp. if fully developed for peaking purposes. The latter would depend on future developments of power in Alberta, such as other hydro sources, atomic energy or provincial interconnections.

Description of Brazeau Drainage Basin

The Brazeau River rises in the eastern slopes of the Rocky Mountains and flows north and east for some 200 miles before discharging into the North Saskatchewan River (Figs. 1 and 5). The upper river basin is dominated by precipitous mountains, from which the river escapes in the vicinity of Cardinal Site. However, the river continues to flow through a 100 ft. to 200 ft. deep canyon to the Frontal Site, with its adjoining drainage basin heavily wooded with frequent muskeg and perched ground water areas. Vehicular access to this area, as yet, is limited to the Nordegg-Edson forestry road, crossing the Brazeau at the Cardinal Site. Downstream from the Frontal Site the river gradient is flatter and the banks fall away. With the exception of a possible site at Elk, no suitable power sites exist until the Brazeau Dam Site is reached, where the river again enters a canyon. The basin adjoining this reach of the river is rolling and wooded, with extensive muskegs, the latter difficult to traverse. Rock outcrops are found along most of the river. The formations progressively change from hard limestone and sandstone in the upper river to softer sandstones and shales in the lower reaches.

Although considerable exploration has been carried out in the Brazeau area for coal and more recently, oil, there has been no economic development except for small lumbering operations. The remoteness of the area and the difficulty of travel within it, have no doubt hampered the establishment of permanent habitation. In this respect, it is interesting to note the following quotation from "Indians of Canada" written by Dr. Diamond Jenness, the eminent Canadian Anthropologist:

"When the Dominion was discovered, its inhabitants, if we may trust one of our foremost authorities, (J. Mooney: 'Aboriginal Population of America'), numbered only about 220,000; yet they roamed over all the territory from the Atlantic to the Pacific, and from the Great Lakes to the Arctic Coast. There was only one section of the country (apart from the mountain peaks and some islands in the Arctic Archipelago) to which perhaps no tribe laid claim, namely, a tract of a few hundred square miles in the foothills of the Rocky Mountains between the headwaters of the Saskatchewan and Athabasca Rivers."

Hydrologic Investigations

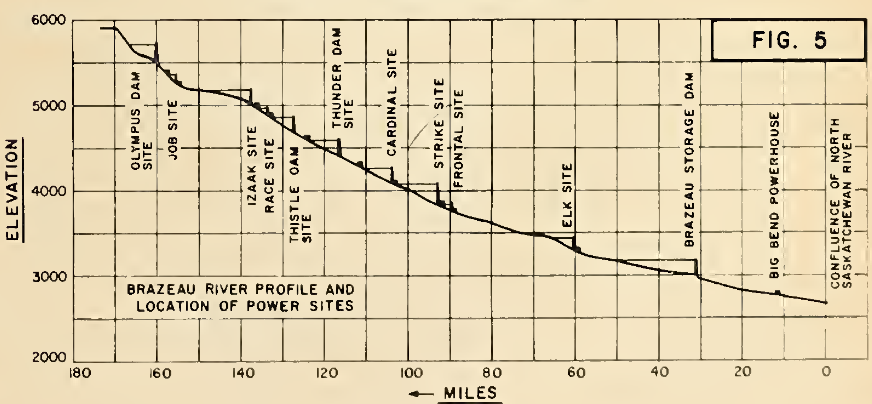
The inaccessibility of the river prevented the establishment of continuous flow measurements until April, 1957. During the summer of 1959, when the investigations were being made, records for only two complete summers were available, along with spot measurements during the winter months of November to April. These records were correlated with those of other rivers in Alberta, on a weekly and total inflow basis during the reservoir filling and drawdown periods. However, the record was so short that correlation results alone were not considered adequate, and a detailed comparison was made of drainage area characteristics such as, proximity to the Brazeau River, the relative elevations, the proportion of glacier, mountain, foothill and prairie drainage, and river slopes. In the final analysis, the comparisons were limited to those rivers where adequate water records were available, as there is little value in a comparison of two rivers with ouly a few records on each.

Of all the rivers available for study the North Saskatchewan River at Rocky Mountain House (referred to hereafter as R.M.H.) was found to be the most comparable to the Brazeau at Big Bend. Measurements at R.M.H. began in 1913, but there are several years where flow data are missing and others when only open water records are available. The downstream station, Edmonton, has a complete record, however, and a comparison between the stations showed that a long term correlation exists. By inference, it seemed clear that a similar correlation should be possible between Edmonton and the Brazeau River, in spite of somewhat dissimilar drainage areas, as the latter contributes the largest single increment of flow to the river between Rocky Mountain House and Edmonton. The correlation between recorded Brazeau and Edmonton flows is also fairly good so that it was possible to prepare a 45-year record for the Brazeau River by using two stations on the North Saskatchewan River. The computed flows were used to determine possible storage volumes, corresponding dam height requirements and energy production. Total inflow for the reservoir filling and drawdown periods were sufficient for preliminary power output calculations as the large reservoir gives a high degree of regulation. The annual run-off at Big Bend is estimated to range from 940,000 to 2.7 million acre feet with an average of about 1.3 million acre feet. Rainfall analysis for run-off computations was not attempted since suitable records are not available in the upper basin.

Historical Floods

No hydrometric measurements for major floods are available for the main stem of the Brazeau. The four years for which records are now available all had low floods. In 1915, flood peaks were estimated on some of the tributaries by O. H. Hoover, of the Department of the Interior. A tabulation of these and other major floods

Fig. 5. Profile of Brazeau River.



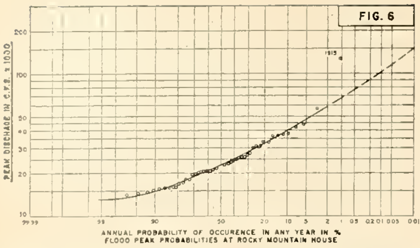


Fig. 6. Flood Probability Curve, North Saskatchewan River at Rocky Mountain House.

on neighboring rivers is shown on Table 1. The 1915 flood is the largest flood that has been recorded on the North Saskatchewan at either the R.M.H. or the Edmonton station. The maximum mean daily flow in 1915 at R.M.H. was 130,000 c.f.s. and dwarfs the second highest recorded flood of some 56,000 c.f.s. in 1952.

it is fairly certain that the 1915 flood is the largest flood in the last 100 years on the North Saskatchewan River. In fact, a flood frequency study such as that shown in Fig. 6 for the R.M.H. station suggests that the 1915 flood might even be equivalent to a 1 in 10,000 year flood. The position of the 1915 flood with respect to the best fit line through all of the other recorded floods since 1913 on this plot illustrates (as other authors have stated) the limitations of probability curves. However, the unusual nature of the 1915 flood is clearly demonstrated and there can be little doubt that it is representative of a much longer time than the actual period of record. The probability curve also gives an indication of the probability of lesser floods which are assumed for design during construction.

TABLE 1

River	*Drainage Area Sq. Miles*	*Recorded Peak Flow C.F.S.*	*Run-off Intensity C.F.S. per Sq. Mile*	*Year of Flood*	*Remarks*
1. Southesk	176	3,840	22	1915	(i)
2. Blackstone	320	30,420	95	1915	(i)
3. Brown	80	11,980	150	1915	(i)
4. Chungo	77	9,350	121	1915	(i)
5. North Saskatchewan at Rocky Mountain House	4,220	145,000	34	1915	
6. North Saskatchewan at Edmonton	10,500	204,000	19	1915	
		192,000	18	1899	(ii)
		166,000	16	1900	
7. Clearwater	1,210	41,000	34	1915	
8. Elbow	460	25,200	55	1932	
9. Bow at Calgary	3,136	99,000	32	1897	
10. Bow at Banff	852	14,100	13	1923	
11. Old Man at Cowley	730	27,300	37	1923	
12. MacLeod at Edson	2,100	75,000	34	1954	
13. Brazeau at Big Bend	2,138	112,000	53	1915	(ii)

(i) Estimated from slope-area measurements made after flood passage.
(ii) As estimated, see text.

The second largest flood at Edmonton occurred in August, 1899, when the stage reached a peak of about 192,000 c.f.s. as compared to the 1915 peak of 204,000 c.f.s. The 1899 flood is described briefly in the Government Hydrometric Report of 1915, and in the newspapers of the period.

Another large flood is said to have occurred in August, 1900, on the North Saskatchewan. Curiously, information regarding this flood is even more scarce than for the 1899 flood. The available information indicates that the river at Edmonton may have reached a peak of about 166,000 c.f.s. There are also a few references to high water levels prior to 1899 but these have been attributed to ice backwater conditions. The most notable flood stage of recent years occurred in August, 1954. Although not as large as the summer floods of 1899 and 1900 it was nevertheless an unusually high flood for August.

As a result of these investigations

As a check on the relative sizes of floods of rivers in Alberta draining easterly from the Rocky Mountains, the maximum recorded floods were plotted as shown on Fig. 7. The enveloping curve through the 1915 floods at R.M.H. and Edmonton is above all other recorded floods.

A flood of 112,000 c.f.s. as derived from the 1915 flood at Rocky Mountain House, was assumed as the normal design flood for the Brazeau Storage Development. It should be noted that this assumed 1915 type flood is probably much greater than that which actually occurred on the Brazeau in 1915. Although a direct comparison is not possible because of the channel storage at high flood stages, a comparison of the recorded floods on the North Saskatchewan shows that the Brazeau flood in 1915 was probably less than 90,000 c.f.s.

Cause of Large Floods

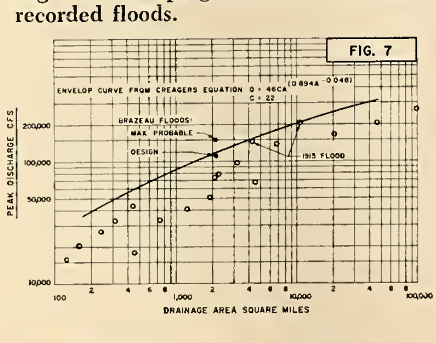
As a result of the extensive study of floods on the rivers comparable to Brazeau, and draining from the eastern slopes, it has been concluded that snow melt plays a minor role in major flooding. From accounts of the floods in 1915,[4, 5] rainfall is judged to be the chief cause of the flood. Snow melt may have contributed to a saturated drainage basin condition resulting in a high rate of run-off when the rainfall occurred. The August, 1899, flood on the North Saskatchewan River was in no way affected by snow melt. Discharge records for the high mountain streams, similar to the headwaters of the North Saskatchewan at Brazeau, show no flood even approaching the intensity of the 1915 flood. Prominent among the reasons for this apparent lack of flooding are: precipitation at the higher elevations is apt to fall as snow; if rain does occur the snow pack absorbs it and thus retards the run-off; and the temperature changes in the higher altitudes are likely to be more moderate than at lower elevations.

Maximum Probable Flood

It is common practice to design dam and reservoir structures for a flood in excess of any that has been recorded on the stream itself or on some other river nearby. The methods used to estimate such a flood usually employ the principle of combining all conceivable worst conditions. The resulting flood may then be termed the maximum probable flood. While the principle is fairly straight-forward the worst conditions to be used are debatable. It is here that the designer must draw a balance between being ultra-conservative, usually at greatly increased costs, or taking some degree of calculated risk, thus reducing the costs. This practice should vary with the size and importance of the structure. For large earth dams a small degree of risk with increased costs is usually justified on the basis of safety of the dam and downstream property.

The Maximum Probable Flood was estimated by analysis of historic storms and flood hydrographs. Rainfall volumes were determined from

Fig. 7. Enveloping curve of maximum recorded floods.



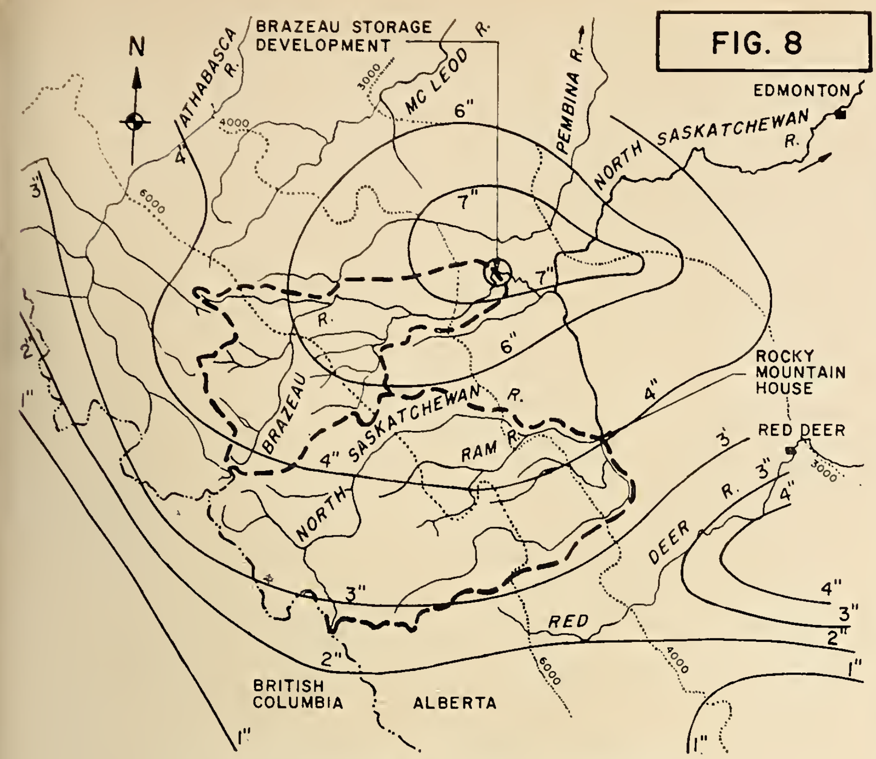


Fig. 8. Isohyetal map for maximum probable flood.

isohyetal maps prepared for several severe storms in Alberta east of the Rocky Mountains. Where possible, floods associated with these rainfalls were studied to determine ratios of rainfall to flood run-off. At the same time, these and other flood hydrographs were examined and an estimate made of ground water and subsurface flows, normal recession curves, and peak-volume ratios after deduction of the base flows. The hydrograph of the largest flood on record, 1915, was analyzed but no direct comparison could be made with rainfall since the existing meteorological information was inadequate.

These comparisons of hydrographs and rainfalls, although approximate, were judged suitable for use in estimating a hypothetical flood on the Brazeau. The date and shape of the most severe recorded storm was later substantially confirmed by studies made by the Meteorological Branch of the Department of Transport, Toronto.[6]

This selected storm was transposed a distance of about 35 miles perpendicular to the Rockies and towards the Brazeau drainage area in such a way that the isohyetals were not deformed appreciably and so that no more than 3 in. of rainfall occurred on the highest regions. The result of this transposition is shown on the isohyetal map, Fig 8. It was arbitrarily assumed that the basin was heavily saturated from previous rains and that 90% of the rainfall would run off. A flood peak of 150,000 c.f.s. was obtained from this analysis and has been termed the Maximum Probable Flood.

Flood Routing

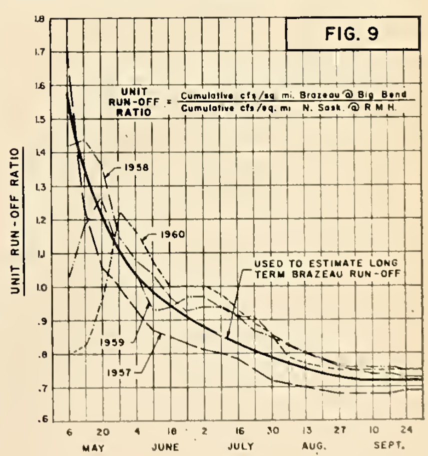
The large reservoir provided by the Brazeau storage dam, and the fact that the water level would be below full supply level when the floods are likely to occur, immediately suggested that considerable savings could be realized by using the reservoir storage (flood routing) to reduce the size of the flood to be passed through the spillways. More emphasis was placed on this aspect when site conditions revealed that a large spillway would be extremely costly, particularly as the initial dam is built to elevation 3175, with good prospects of a future raise to elevation 3210.

A flood routing scheme was therefore developed for the Brazeau Reservoir on the basis of its future operation and adapted to the needs of the initial development. The chief requirements are to ensure reservoir filling, and to utilize the reservoir volume to contain large floods. For this purpose, it was necessary to determine the distribution of flow throughout the filling period and calculate reservoir filling curves both during and after construction of the dam. For this study the R.M.H. station was again used. It was found that the Brazeau unit run-off was generally higher than that at R.M.H. in early summer, but tapered off more quickly towards fall. This phenomenon is judged to be the result of a larger proportion of permanent glacier on the North Saskatchewan drainage area. A long term record of weekly flows at Brazeau was derived by using the ratio of cumulative weekly flows on the two rivers as obtained from the filling seasons 1957 and 1958. Curves representing these calculated ratios are shown on Fig. 9, together with the curve adopted for use. It is anticipated that there may be considerable divergence from this curve in any given year, particularly when considering short periods. The ratios of unit flows for the filling periods 1959 and 1960 are also shown on Fig. 9. These suggest that the initial curve developed from 1957 and 1958 flows may be conservative, and that adjustments may be necessary when more data becomes available.

The minimum years, as derived for Brazeau from the R.M.H. flows, form the basis of the reservoir filling curves shown on Fig. 10, and these together with the spillway facilities form the basis of future reservoir operation.

The curves are calculated to ensure filling of the reservoir in all years, barring the occurrence of a more severe drought than yet experienced. A comparative study of flood volumes, similar to that made for flood peaks (Fig. 7) showed a corresponding exponential variation with drainage area. This relationship was used to estimate the flood hydrograph shown on Fig. 11 for the 1915 normal design flood. It is believed that this method of estimating flood volumes is conservative when records from a large drainage area are used to estimate the flood on a smaller drainage area, since the base length of the hydrograph remains basically unchanged. The normal design flood was assumed to occur at anytime during June or July. During these months

Fig. 9. Run-off distribution comparison.



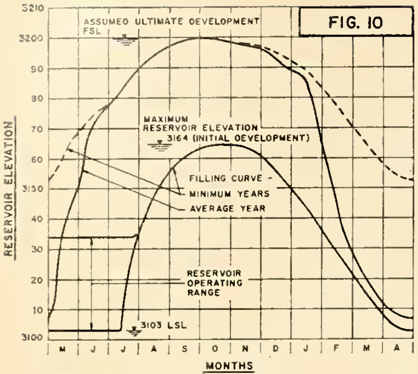


Fig. 10. Reservoir operating rule curves for use after power is installed.

the reservoir would be held low to provide sufficient flood storage to reduce the flood inflow of 112,000 c.f.s. to 43,500 c.f.s. outflow from the spilling facilities.

As the reservoir fills during the summer, the flood-routing capability is reduced and particular attention was therefore given to floods that might occur in August and September. The 1899 flood is the second largest flood known to have occurred on the North Saskatchewan River, and is the largest flood known to have occurred in the late summer. The 1915 Hydrometric Report indicates a flood peak of 180,000 c.f.s. at Edmonton. Additional information about this flood was obtained from files of the Edmonton Journal in the Archives in Ottawa. In particular the issue of October 12, 1899, contained extracts from the diary of J. Stewart, a Dominion Bridge Engineer, who had recorded the water levels in relation to the piers of the Low Level Bridge which was being built at that time. Using these elevations as a guide a flood hydrograph was prepared showing a peak discharge estimated at 192,000 c.f.s. The flood was remarkable, not only because of its peak of 192,000 c.f.s., but because it was followed by three smaller stages estimated at 107,000, 98,000 and 74,000 c.f.s. respectively. The stage began rising on August 16 and finally subsided on September 2. The 1899 type flood as estimated for Brazeau is shown on Fig. 11. Smaller floods con occur at later dates but do not control the design since the spilling facilities provided are ample without flood routing.

The maximum probable flood hydrograph as found from the rainfall analysis, and shown on Fig. 11, was assumed to be possible in the months of June or July. A comparison of these three floods is shown on Table 2 with the corresponding maximum reservoir elevations, assuming flood routing in each case.

TABLE 2
Comparison of Floods

Flood	*3 Day Flood Volume Ac. Ft.*	*Peak C. F.S*	*Max Res. Elevation*
Normal Design	467,000	112,000	3164
Max. Probable	500,000	150,000	3167
Late Summer	453,000	110,000	3167

Spilling Facilities

Spilling from the reservoir is accomplished through the pumphouse and by two concrete conduits under the main dam. The latter are gate-controlled conduits with a capacity of 38,500 c.f.s. The pumphouse (Fig. 2) is designed to pass a maximum of 26,000 c.f.s. into the canal, from which water can be discharged through the Big Bend turbines and a side exit spillway.

Design Flood During Construction

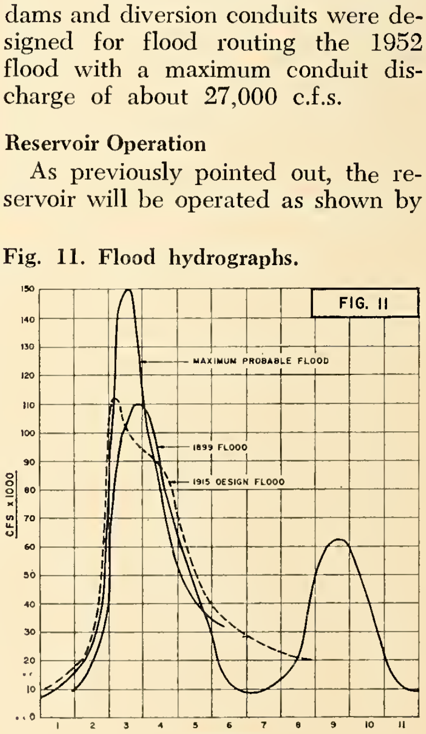
The 1952 flood on the North Saskatchewan River at R.M.H. was used as a pattern for the construction flood at Brazeau. This is the second highest flood on record at R.M.H., and is indicated by the flood frequency curve, Fig. 7, to have a frequency of about 1 in 30. However, based on comparisons with floods on other rivers, the frequency curve for the North Saskatchewan at Edmonton and rainfall analysis, it was considered to have a frequency of occurrence of 1 in 20 years. The corresponding flood on the Brazeau was calculated to have a maximum mean daily flow of 43,500 c.f.s.

During construction of the main dam the river was diverted through two concrete conduits. The cofferdams and diversion conduits were designed for flood routing the 1952 flood with a maximum conduit discharge of about 27,000 c.f.s.

Reservoir Operation

As previously pointed out, the reservoir will be operated as shown by the rule curves on Fig. 10. These curves are the result of a trial and error balance between reservoir capacity, spilling facilities and operating requirements.

Fig. 11. Flood hydrographs.



During the summer months of May, June and July the reservoir will be held at low level to provide adequate room for any large flood that might occur. The inflow will be normally by-passed by the pump-turbines to the canal and thence through the powerhouse. Inflow in excess of the pumping capacity will be by-passed through the conduits. The filling curve will be followed as closely as possible so that there will be no danger of the water level exceeding elevation 3164 with a normal design flood, or in the case of the extreme flood, elevation 3167. Drawdown during the winter will follow the general pattern shown by the curve on Fig. 10, which is based on the storage and load requirements in a typical winter.

Summary

The Brazeau Storage and Power Development will serve three main purposes:

1. Storage releases during the winter will increase the flow in the North Saskatchewan River both before and after power is developed.
2. It will provide peak capacity and energy for the power needs of the Province.
3. Flood peaks originating on the Brazeau will be materially reduced by the storage in the reservoir.

Acknowledgements

The authors wish to thank the Alberta Provincial Government and Calgary Power Ltd. for permission to publish, and to acknowledge the work of colleagues in Calgary Power Ltd. and Montreal Engineering Company Limited who contributed a large amount of background data and helped in preparing the manuscript.

EIC

References

1. Report on **Proposed Hydro-electric Development Scheme on the Brazeau River** Water Power Branch, Ottawa, 1915 by C. H. Attwood.
2. Brazeau Storage and Power Development Agreement.
3. **Economic Evaluation of Alternative Energy Sources** by G. A. Gaherty et al, World Power Conference, October 1962.
4. Progress of Stream Measurements for the Calendar Year 1915.
5. **Report of the Survey of the North Saskatchewan River from Edmonton to Lake Winnipeg, 1910-15,** C. R. Voligny C.E.
6. **Storm Rainfall in Canada,** Department of Transport, Meteorological Branch, Toronto.
7. **Design and Construction of the Brazeau Dam** by J. K. C. Mulherin, P.Eng., to be presented at the E.I.C. general meeting, June, 1962.

How to specify roll-forged flanges without really trying (and get 'em within 14 days)

Our new ordering kit provides you with a convenient, fool-proof way to specify *any* flange you need. Flanges are available in straight carbon, alloy ferritic steels, and many austenitic steels. All are made according to strict ASTM specifications. Best of all, we ship *any* flange you need up to 80″ diameter and 10″ face within 14 days from the time you order . . . only Canforge makes them in Canada. Not only save time but also duty and exchange. We'll be glad to send you an ordering kit. Your request for it, quotations, or more information, will receive our immediate attention. Write:

CANADA FOUNDRIES & FORGINGS LTD. **Canforge** **WELLAND, ONTARIO**

Discussion

75 YEARS OF STRUCTURAL STEEL

W. C. Kimball,
Assistant Chief Metallurgist,
The Algoma Steel Corporation Limited.

The Engineering Journal, September, 1962. page 35

Discussion by R. S. Eadie

Vice-President and Director of Engineering, Dominion Bridge Company Limited, Montreal;

I read Mr. Kimball's paper with much interest and congratulate him on the splendid summary he has presented on the development of steel manufactured over the last seventy-five years.

In discussing the paper, I am approaching the subject from the position of a fabricator and would like to add some further data from that point of view.

It is perhaps not generally realized the great development that has taken place in the basic steel industry in Canada, even in the last forty to forty-five years, or since the end of the First World War.

Previous to that time, as far as the production of structural steel, such as bars, angles, beams, channels and plates, was concerned, our Canadian mills could only supply bars, small angles, channels and beams, and plates up to about 14" wide. It naturally followed at that time that Canadian designers and fabricators had to depend on British, American and European mills for their material and were largely governed in their designs by the specifications in vogue in those countries.

Since that time, our mills have expanded their production from about a capacity of 2,000,000 tons per year to something in the neighbourhood of 7,250,000 tons per year and have also expanded the range of products which they can produce. Today we can obtain from Canadian mills, angles up to 8 x 8", beams up to 24", channels up to 15", columns up to 12 x 12" and plates up to 113" wide.

About the only structural sizes not now rolled in Canada are beams over 24" deep and plates over 113" wide. The demand for these sizes is, of course, somewhat limited and does not yet warrant the installation of the necessary expensive rolling equipment.

The change in the variety of product and the increase in tonnage produced have, as has been outlined by the author, gone hand in hand with the development of the quality of the product. This improvement in quality has kept up with that of other countries and, I think, in some fields at least, has gone ahead of other basic steel producers.

There are one or two points on which I would like to add some information to that given by the author. In regard to the Firth of Forth Bridge, which was designed in 1881, and on which work started in 1883, a paper published in "Engineering" on February 28, 1890, states that a total 61,200 tons of steel was produced by the Siemens-Martin open-hearth process for use on that project. The tonnage was largely made up of plates, angles and beams. For tension members, the steel was specified to have an ultimate resistance of 30 tons minimum and 33 tons maximum with a minimum elongation of 20% in 8". For compression members, the ultimate resistance of the steel had to lie between a minimum of 34 tons and a maximum of 37 tons, with a minimum elongation of 17% in 8". The working stress was required not to exceed 1/3 of the ultimate, and was reduced for members subjected to pulsating or reversing stresses.

There is no reference to any chemical requirements, but a tensile test was called for on one plate out of every fifty. Bending test specimens 2½" wide were also required to be cut from every plate and bar and bent to a radius of 1½ times the thickness with the ends of the test pieces closed. It is stated that, "the failures of the steel under test were of the rarest occurrence."

With regard to nickel steel, it is interesting to note that over 16,000 tons of such material, with a minimum specified yield point of 50,000#/sq. in. was used in the construction of the Quebec Bridge which was designed in 1910.

Referring to welded buildings, two early examples should be mentioned.—The Western Hospital at Atwater Avenue, and the Canadian General Electric building on Beaver Hall Hill, both in Montreal, were built in 1931 and were both completely field welded.

The author mentions the confusion arising at the present time both at the mills and at the fabricators plants, due to the greater variety of steels being offered. This confusion is very serious and will not be overcome by rewriting specifications. The great difficulty is to identify the various grades of steel. This can only be done by the mills instituting a foolproof system of identification for the different grades of steel, starting at the ingot stage. The identification system must be such that the grade of each piece of steel can be determined at all stages of fabrication and in the finished structures. Present methods do not provide assurance of proper identification of each piece with the result that considerable extra expense is caused the fabricators in carrying identification marks through their fabrication processes. Unless a proper system is devised, the use of the newer steels on small size jobs will be limited. Of course, on large projects, it is always easier to control and identify special materials.

Three factors, other than strength which govern the use of any particular steel by a designer, are—

the cost strength ratio

the deflections encountered in the finished structure.

the ratio of the yield point to the ultimate strength.

In some cases it is more economical to use a low strength steel since the extra cost per pound of the higher strength material is too great to compete. The designer needs to watch carefully that the deflections or movements encountered in the finished structure will not be excessive where high strength steels are used. This problem, for example, is encountered in the design of high rise buildings where the wind deflection must be kept below a definite figure in order to make the building acceptable for public use. In modern high strength steels, the margin between the yield point and the ultimate strength has been reduced. Caution should therefore be exercised in arriving at design stresses for any structure by giving careful consideration to the factor of safety on the ultimate as well as on the yield point stress.

Author's Reply:

I wish to thank Mr. Eadie for his kind discussion of my paper, particularly the clarification of some points regarding the Firth of Forth Bridge. Apparently his companies' library had more complete references than those that I was able to find, and I feel that both he and his company should be congratulated.

I must agree with Mr. Eadie that the writing of new specifications is not a simple way to improve the economy of building construction. The use of various grades of steel is something that requires great thought and care on the part of the designer, since the new steels being offered are not always the most economical steels for a particular structure.

Identification of steel in a completed structure is certainly a serious problem. This matter is being looked into by a committee of the Canadian Standards Association and is also receiving very serious consideration by the Canadian Institute of Steel Construction. While there is no simple solution to this problem since it has technical facets as well as economic ones, I am sure that in the near future a reasonable solution will be found.

To have a real breakthrough on steel construction it would be necessary to find some way of increasing the modulus of elasticity of steel. So far we know of no solution to this problem, but I can only hope that some metal physicist may find a solution one of these days.

(Continued on page 72)

PIE IX STREET BRIDGE, MONTREAL, P. QUE.

BOUT-DE-L'ILE BRIDGES, REPENTIGNY, P. QUE.

Dufresne Engineering Company Limited

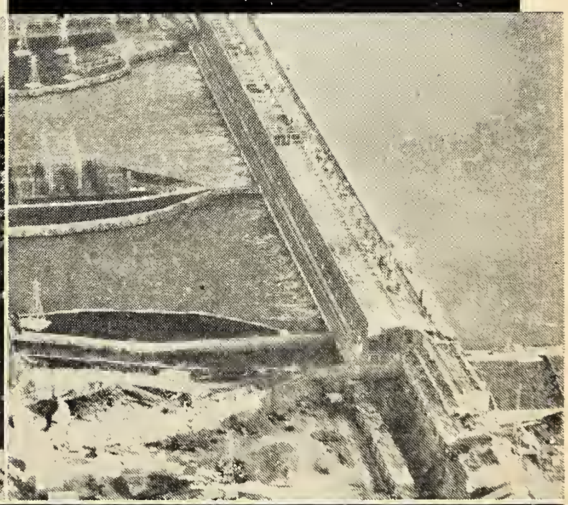
(GENERAL CONTRACTORS)

The Company was established in 1922 and its larger contracts have included bridges, dams, hydro-electric developments, wharves, viaducts and tunnels. Among the bridges are those at Bout-de-l'Ile, Pie IX Street, Viau Street, Ile Perreault, Ste. Rose, St. Eustache, Bordeaux, the substructure of Jacques Cartier and Mercier, all in the Montreal area, Chambly, Three Rivers, Gaspe and Valleyfield.

Dams and hydro-electric developments include those at Passe Dangereuse on the Peribonka River, Rapid No. 7 at Abitibi, Lake Metis, Lake Morin, Power Houses Numbers 2 and 3 which develop 1,700,000 K.W. at Beauharnois, the first and second stage power houses which develop 1,500,000 K.W. at Bersimis, and Twin Falls Development, Labrador, 240,000 H.P. Other major contracts include the Windmill Point Wharf, Sorel Wharves, and the Wellington Street Tunnel under the Lachine Canal.

JACQUES CARTIER BRIDGE,
MONTREAL, P. QUE.

HYDRO-ELECTRIC POWER DEVELOPMENT,
TWIN FALLS, LABRADOR, NEWFOUNDLAND.



HYDRO-ELECTRIC POWER DEVELOPMENT,
BEAUHARNOIS, P. QUE.

1832 PIE IX BLVD. LA. 1-2154 MONTREAL 4, QUE.

Discussion

(Continued from page 70)

Engineers and the Canadian Economy

J. P. Francis,
Director, Economics and Research Branch, Department of Labour, Ottawa

The Engineering Journal, September 1962 page 47.

Discussion by William Bruce M.E.I.C.

Mr. Francis has taken us to one side and asked us to view with him, through the eyes of an economist, engineers in relation to the Canadian economy, and to examine certain facts and observations.

It is quite evident from the paper that he quite deliberately chose to present his subject in a provocative manner. While not exactly "flinging down the gauntlet", his statements do more than invite a response, they demand it. Such an incentive makes the role of the discusser a more satisfying one and I am grateful for the opportunity to act in his capacity.

At the outset, I must say that I am avoiding meeting Mr. Francis in pitched battle, for I find myself in agreement with many of his observations. Others, however, I propose to contest or at least to qualify.

One theme of the paper suggests that perhaps engineers in Canada are a favored and privileged group; that a portion of this group exists at the expense of the development of other spheres of activity which might contribute more to the economy of the country; that while perhaps not being "sons of Mary" many of the engineering group are not true "sons of Martha". This is a serious matter and worthy of our consideration.

It appears that engineers in Canada face a somewhat bleak future. On the one hand, business school graduates, masters of commerce and economics studies, psychology and sociology majors and others intend to move in on the lush, top administrative jobs as well as on some of the lower echelons of management, now presently filled by persons of engineering ilk, while at the other end, routine technical assignments and specialties of limited scope will be whipped away by technicians. This may be a good thing. Competition always provides the incentive for improvement both in the quality and in the performance of the individual, and leads to a more efficient and industrious work force.

There is a common tendency (in other circles) to think of engineers as "plumbers" best able to act in limited technical areas, and to consider engineering education as a narrow restrictive field. This is an outmoded concept and it is definitely not so, as a careful examination of present day engineering curricula will reveal. I say the "proof of the pudding is in the eating". The many non-engineering jobs which are filled by persons who have had an engineering education are, of course, held on a competitive basis. If alternative types of education will provide a better preparation for certain industrial jobs, then the persons so trained will be in great demand. It is worth noting that many aspects of studies in industrial administration, business and personnel management require, for effective assimilation, a maturity of mind and a degree of experience not readily reached by the young undergraduate. This, in fact, makes studies in these areas more suitable for treatment at post graduate level, and this is the case at many leading universities. As a consequence, a considerable number of engineering undergraduates, after gaining the B.Eng. degree continue their studies in these fields with notable success.

In the matter of the discrepancy between the relative numbers of engineers in Western Europe compared to here, it may be due in part to the method of classification. We judge the growth in the numbers of engineers primarily in terms of the number of B.Eng. degrees issued. Our tendency is to class as an engineer one who has taken an engineering undergraduate education regardless of the subsequent field of activity he pursues. Many such persons work in rather peripheral and fringe areas of engineering and technology, but they still hold allegiance to the engineering profession. In my opinion, it would be wrong to estimate the strength and capability of our engineering work force through numbers alone.

The fact that about twice the proportion of Canadian engineers are engaged in administration compared with the U.S., whereas only about one-fifth of the proportion are engaged in research and development is significant. It suggests that since much of our manufacturing industry is primarily concerned with operation, maintenance, marketing and sales, and with research, design and development being minor or negligible, that the type of engineer which evolved predominantly was one more closely associated with supervisory and banagement functions. As a measure of efficiency, he in fact came to serve in two combined functions, technical and managerial, the first being the primary requisite. In a company which is completely self-sufficiest in all phases of industrial activity, there is a greater segregation and specialization of duties. Since Canadian industry in most instances does not embrace all the facets, its compositional character will definitely be at variance with that in the U.S. However, there is considerable evidence that research and development activities in Canadian industry are rising noticeably and they will be a much more significant feature of industrial activity than heretofore.

Mr. Francis states that "technically, engineers will need to be more highly educated than at present," and also "the vast majority of engineers now being produced in this country are still entering the work world with only an undergraduate degree".

Advanced education is an essential requirement in all rapidly developing fields and this is certainly true in the field of technology. To meet this need, both the undergraduate and graduate studies in engineering have been undergoing major and significant changes. The engineer who completed his undergraduate studies only five years ago would be aware of many differences in today's curricula. The need for a much higher level of knowledge in mathematics and the basic sciences in order to acquire proficiency in the understanding and use of the expanding engineering sciences have made their mark on the engineering curriculum. These changes have been accommodated by elimination of purely technique courses and by demanding an even greater disciplined intellectual effort from the student. It is important to remember that at a university, the evolution of the undergraduate curriculum is based more on ensuring that the better students are fully able to pursue graduate studies at the best universities both here and abroad, rather than on the immediate needs of industry, although the latter factor is in no way neglected. While industry may acquire particular national characteristics, education at the university level adheres to an international pattern.

Graduate study and research activities in Canadian engineering schools are in a period of rapid growth and development. Last year graduate students in engineering registered at Canadian universities amounted to slightly more than 6% of the undergraduate enrolment, and in addition, a considerable number of others were studying abroad, while others undertook studies in commerce, economics and business administration. At the master's level in Canada, there were 750 students in engineering, compared with 853 in the physical sciences, and at the doctorate level, 181 vs. 777. The disparity at Ph.D. level will certainly decrease. Last year 50% of the graduate students in engineering at McGill were Ph.D. candidates and indications are that it will be greater next year. The response to the need for more highly educated engineers is certainly evident.

Another matter upon which Mr. Francis touched was the importance and place of technicians in the industrial framework. I agree with him that this is an area of activity which is becoming exceedingly important and one in which the educational facilities in Canada have been lacking. Industry has relied almost completely upon immigration as a source of such personnel. It is true that steps are now being taken to remedy the lack of such training facilities and many building programs are in evidence. However, it is most essential that the curricula of such schools be carefully set out, to see that they extend to high enough levels, that they adequately complement the changing engineering educational requirements, and that they meet the specific needs of industry.

Finally, a further phase of matching the education of the engineer to meet the needs of the economy might be found in a combined B.A./B.Eng. degree as is now done in other professions. At McGill, we have a five-year undergraduate engineering program following junior matriculation. It seems entirely feasible without two much alteration and with no change in standards of the engineering course to set out a combined B.A./B.Eng. program which could be accomplished in six years. Probably only a minority of engineering students would elect this program, but it would allow for a much greater variety of comprehensive studies and a much broader based education for some, fitting them for a wider range of occupations.

In conclusion, since Mr. Francis undoubtedly asked that we defend our position, I return to the rather touchy theme as to which is the tail and which is the dog. It could be, of course, that instead of the polished graduate of a business management school hiring an engineer to look after the technical details of the business, in Canada the engineer-manager will simply pick up a few bright commerce-economics graduates to ensure that his product is marketed at a profit.

Discussion by
David N. Solomon

Although I have made every effort to do so, I cannot find any specific points with which to disagree or take issue with Dr. Francis' interesting and excellent paper. Dr. Francis explains recent changes in the number of engineers in Canada by allocating growth to changes in the labour force as a whole, to the exceedingly rapid rates

(Continued on page 74)

Swagelok®

[B]ULKHEAD
[CO]NNECTIONS

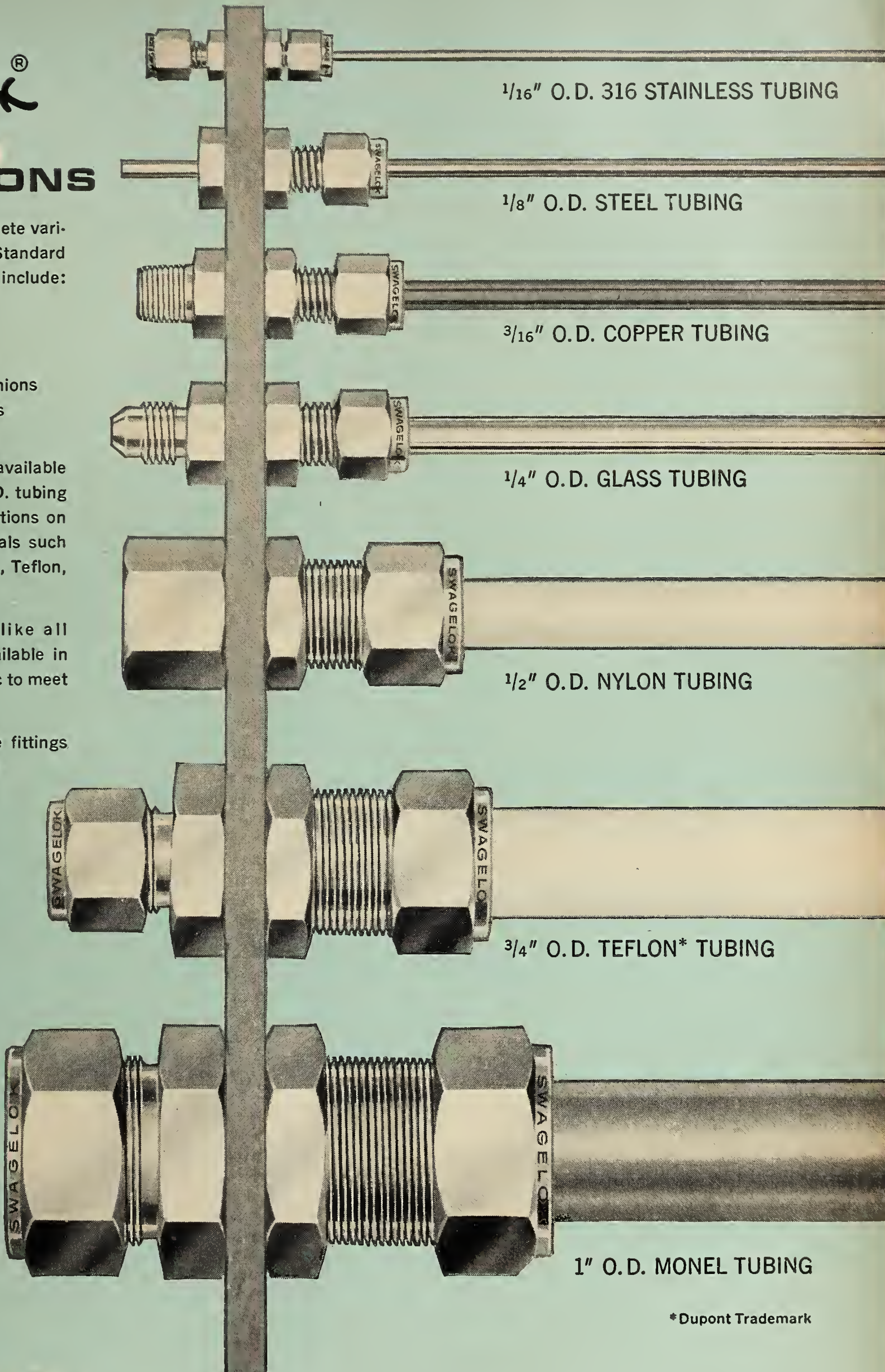
[…]wagelok has such a complete vari[ety of] Bulkhead Tube Fittings. Standard [Swagel]ok Bulkhead Tube Fittings include:

- [Bu]lkhead Unions
- [Bu]lkhead Adapters
- [Bu]lkhead Male Connectors
- [Bu]lkhead Swagelok to AN Unions
- [Bu]lkhead Female Connectors
- [Bu]lkhead Reducing Unions

[Swagel]ok Bulkhead Fittings are available [in size]s for 1/16" through 1" O.D. tubing [and ca]n make leak tight connections on [a wide] variety of tubing materials such [as sta]inless steel, monel, Nylon, Teflon, [glass,] copper, steel, etc.

[Swag]elok Bulkhead Fittings, like all [Swage]lok Tube Fittings, are available in [any m]achineable metal or plastic to meet [your p]articular requirements.

[Reme]mber, whether you require fittings [for the] simplest application or the [most] demanding, whether it is [unusu]al tubing material, unu[sual fi]tting material or unusual [fittin]g types, Swagelok Tube [Fittin]gs solve your problem.



*Dupont Trademark

Swagelok TUBE FITTINGS SOLVE YOUR PROBLEMS

CRAWFORD FITTINGS (CANADA) LTD., NIAGARA FALLS, ONTARIO, CANADA

Discussion

(Continued from page 72)

of growth of industries which employ large numbers of engineers, and most recently to increases in the level of technical skills required in certain of these industries. Although easy to understand this is a far more sophisticated approach than the usual uncritical attempt to explain growth in the number of engineers in terms of growth in gross national product or some other very crude relationship. Dr. Francis, quite rightly I think, draws attention away from the technical problems involved in forecasting manpower requirements. His theoretical interpretation or explanation of recent history, on the other hand, lays out a set of dimensions which ought to be basic considerations for anyone attempting forecasts. I hope we can look forward to the application of these notions by Dr. Francis and his colleagues to the problems of forecasting future requirements.

I would like to make one or two comments which were stimulated by reading Dr. Francis' paper. While forecasting future requirements is not the central concern of the paper, it is a matter of interest. The allocation of resources is a process which goes on in any social system, whether it is rationally planned or not. It is, if you will, a natural process. The purpose of forecasting is to make possible a rational plan for the allocation of resources which is expected to be more efficient than the natural, but unseen hand, remarked on by Adam Smith. But most attempts at forecasting have been concerned with occupations which happen to catch the public interest. We have heard a great deal about past, present, and probable future shortages of engineers and scientists. Some medical authorities, both here and in the United States, believe that we will have to double or perhaps triple our annual production of young doctors. Nurses and teachers are in short supply. The Department of National Health and Welfare has recently allocated a very large sum of money to the training of social workers. We are told, and perhaps some of us ought to be thankful, that very soon there will be a terrible dearth of professors. And so it goes. While the efforts of professional groups or sectors of the economy compete for recruits and look out for their own needs are commendable and ought to be encouraged or at any rate tolerated, we must realize that no matter how fast it grows the manpower cake is still a limited one. We are very far from having the comprehensive body of information required to decide how to slice it more rationally than by following whatever sputnik happens to be sailing across the horizon at the moment.

This brings me to another of the points of great interest in Dr. Francis' paper, namely his assumptions as to the relationships between technological change or innovation, economic development, and requirements for highly trained manpower. He regards technological change as the independent variable which produces both economic development and manpower demands. One may also ask, of course, what are the independent variables which produce technological change. Economic development and the size of the trained manpower pool perhaps determine as much as they are determined by the rate of technological innovation. The relationship is circular and I think we do not understand it too well as yet. There is another independent variable, however, in so far as innovation is concerned, and this is a social one: the question of how receptive or resistant a given society is to innovation at any particular time.

That in 1959 only 6% of engineers in Canadian industry were engaged in research and development indicates first, that for obvious reasons a good deal of our industrial research and development is done in other countries, and second, that industrial management in Canada has not been highly receptive to innovation. One hears that in such and such an industry 3% or 6% or what have you is regarded as the appropriate proportion of revenue to be spent on research and development. The scientists and engineers in research and development, sometimes without an assist from their colleagues in production, are hopeful of selling management on a higher proportion, but despite recent changes, it remains an open question as to just how rapidly management in Canada will become more convinced, of the virtues of investing in innovation. There is also the question, of course, of how much investment which produces quite long-postponed returns can be afforded by an economy in our particular state of development. If Dr. Francis is correct in his prediction that engineers will be replaced or succeeded in management positions by graduates of schools of business administration, it is interesting to speculate on what impact this is likely to have on management policies with regard to research and development expenditures and hence on the employment of engineers. My own guess is that it may add something new and help to break down the entrenched conservatism of much of present management, but then maybe I am optimistic about the virtues of university education.

There is hardly an end to interesting points which can be generated by reading and re-reading Dr. Francis' paper and I should like to have touched on a number of others, such as the changes in the work roles of engineers and in engineering education which he forecasts, but time does not permit. We are indebted to Dr. Francis for this stimulating presentation.

Author's Closure

I think perhaps the comments on my paper by Professors Solomon and Bruce bring us back to a basic question: what is the management function which should be performed in business and industry, and how can people be best prepared to perform this function?

It is my contention that the management function is a crucial one for our economic and social welfare, that it involves a terribly difficult task of bringing together men, materials and know-how in a manner which yields an optimum result, that it requires among other things an eagerness to innovate and a willingness to take a chance, and therefore that it should be regarded as a professional activity for which intensive and systematic preparation is necessary.

Now it seems to me that the market mechanism will not by itself spell out clearly the need for professionally trained people to perform management functions of these kinds, although it will throw up warning signals through relatively low productivity and profits, through inabilities to compete internationally, and through poor labor-management relations, that something is wrong. Basically, all the market can do is allocate to management positions the best of the manpower resources which are available and, as I have pointed out, we have a situation where a substantial number of engineers are being allocated to these kinds of jobs.

The market in effect does the best it can with the resources available to it. It is up to us as individuals and as a nation to judge whether or not these resources are carrying out the management function as well as it might be. If, for example, a person with engineering training is one who will not be inclined to take a chance, and if this is an important element in management, then we should either change the kind of preparation which engineers receive or think of making available other kinds of people who have been trained to gamble judiciously and win more often than they lose.

I think to some degree in Canada we have not faced up to the issue of our needs for management personnel and the most appropriate ways of producing such people. In my view we cannot afford to ignore this matter very much longer. We need to realize that technology is only one of the ingredients which goes into the making of a successful enterprise these days. As I mentioned in my paper, there are many others: manpower, finances, labor-management relations, marketing, forecasting, and so on. Basically, the task of management is to mix these ingredients together in such a way as to produce the tastiest cake, the one which will sell better than any other. We should be doing much more than we are in trying to find out what kind of a person can perform this type of function best.

Professor Bruce's comments about the increasing proportion of people receiving undergraduate engineering degrees who are going on to postgraduate work are most encouraging. I am convinced that the engineer of tomorrow, if he is going to work as an engineer, will need much more than a university undergraduate degree. Professor Bruce's comment that the increasing number of technicians which will shortly be produced in this country will need to be trained to sufficiently high levels is also well taken. It seems to me that there is a constant danger of our advanced technical institutes being watered down to nothing more than trade schools.

Professor Solomon pointed out that our understanding of the relationship between innovaton, economic growth and requirements for high talent manpower leaves a lot to be desired. I fully agree with this comment and feel that this is one problem to which economists among others need to give a great deal more attention. Professor Solomon also mentioned that a more sophisticated methodolody for forecasting our requirements for highly trained manpower is badly needed so that decisions affecting the way in which these resources are allocated can be made on a more rational basis than is the case at present. Again, I am in full agreement with this remark and might mention that an increasing amount of research on long-term forecasting is developing both on this continent and in Europe.

THE PRODUCTION AND USE OF AN ANIMATED FILM FOR TEACHING KINEMATICS

G. F. Pearce,
Assistant Professor of Mechanical Engineering,
University of Waterloo

The Engineering Journal, September 1962. Page 51.

Discussion by D. L. Allen

In recent years there has been an increase in the number of excellent educa-

(Continued on page 108)

Kodak

Industrial X-ray Film

Kodak
TRADEMARK

The air is no test ground for aeroplane castings. Radiography with Kodak Industrial X-ray Film finds any and every flaw first!

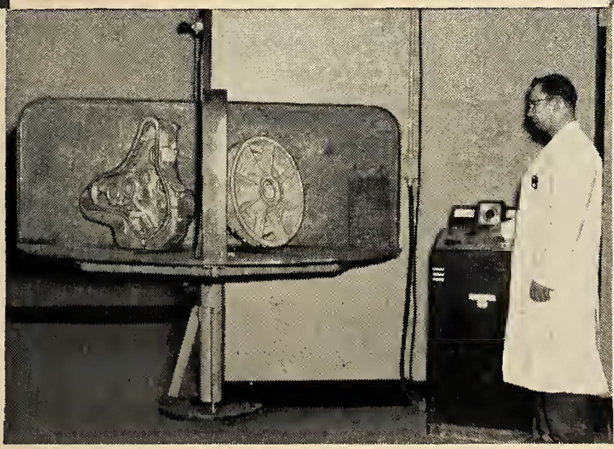
Light Alloys Ltd. of Haley, Ontario supplies castings to more than half a dozen manufacturers of aeroplanes and aeroplane engines. Everything from ski-clamps for commercial aircraft to gear boxes for helicopters is produced. And, almost every casting . . . whether it weighs 4 ounces or more than 120 pounds — is examined in the plant's radiography department. Only radiography gives proof that a casting is sound enough to withstand calculated design stresses!

"Radiography ensures that a casting meets the specifications", explains L. G. Day, plant manager. "Without industrial X-ray we would have no idea of metallurgical soundness. For example, a complex casting could have severe porosity and yet appear satisfactory to the eye. X-rays detect the flaws even in internal passages."

"All our machines are set for Kodak film", says Mr. Laporte, Chief Radiographer. "There is no tendency to fog or streak. Both the film and developing are so superior."

As at Light Alloys Ltd., Kodak Industrial X-ray Film can guarantee the right answers to your inspection problems. Contact your X-ray Dealer or Kodak Technical Representative for the full story. Or write: Canadian Kodak Co., Limited, Toronto 15, Ontario.

Assures safe journey for airbound castings!



Light Alloys' Radiograph Dept. uses a revolving, 4-compartment "turntable" to speed its work. While castings are being radiographed in one compartment, other castings are set up in the other three ready to be radiographed. No time is lost between exposures of film!

CANADIAN KODAK CO., LIMITED
Toronto 15, Ontario

Month to Month

NOMINATIONS FOR OFFICERS, 1963

The report of the Nominating Committee, as accepted by Council at its meeting held on September 7th, 1962, in Digby, Nova Scotia, is published for the information of all corporate members as required by Sections 19 and 40 of its By-Laws.

VICE-PRESIDENTS 1963-65

Zone "A" (Western Provinces)	W. A. Smith, Calgary
Zone "B" (Ontario)	Maj.-Gen. G. R. Turner, Ottawa
Zone "C" (Quebec)	C. E. Frost, Montreal

COUNCILLORS

(Two Councillors to be elected for three years)

Montreal Branch	G. M. Boissonneault, Montreal C. G. Kingsmill, Montreal

(One Councillor to be elected for three years)

Ottawa Branch	A. B. Connelly
Toronto Branch	

(One Councillor to be elected for two years)

Amherst Branch	J. W. Wilson
Baie Comeau Branch	G. W. Scott
Belleville Branch	W. L. Caniff
Border Cities Branch	R. H. Darke
Central B.C. Branch	Fred Joplin
Chalk River Branch	R. D. Page
Corner Brook Branch	Karl Bulins
Eastern Townships Branch	James C. Davidson
Edmonton Branch	Bryan A. Ellis
Halifax Branch	J. G. Belliveau
Kingston Branch	W. B. Rice
Kootenay Branch	R. F. Bailey
Lakehead Branch	Curtis M. Cotton
London Branch	Donald J. Matthews
Lower St. Lawrence Branch	
Newfoundland Branch	G. A. Myers
Nipissing & Upper Ottawa	
North Shore Lower St. Lawrence Branch	
Prince Edward Island Branch	D. I. D. Rozman
Port Credit Branch	D. S. Moyer
Port Hope Branch	J. L. Sylvester
Saguenay Branch	C. C. Louttit
Saskatchewan Branch	K. Allcock
Saint John Branch	Phillip W. Hastings
Saint Maurice Valley Branch	W. A. Pangborn
Sudbury Branch	R. P. Crawford
Vancouver Branch	R. H. Carswell
Vancouver Island Branch	A. R. D. Robertson
Winnipeg Branch	J. Hoogstraten
Yukon Branch	G. B. Starr

Annual General Meeting 1962

Minutes of the Seventy-Sixth Annual General Meeting of The Engineering Institute of Canada held on Tuesday, June 12, 1962, at The Queen Elizabeth Hotel, Montreal, Quebec, between the hours of nine a.m. and twelve noon, presided over by the President, B. G. Ballard, Ottawa, Ontario.

QUORUM, CALL TO ORDER AND NOTICE OF MEETING

The President established that a quorum of Members in good standing was present. The President called the Seventy-Sixth Annual General Meeting of The Engineering Institute of Canada to order at 9:00 a.m. The General Secretary read the official notice of the meeting which, (in accordance with Section 52 of the By-Laws), had been mailed to corporate members twenty-one days before the date of the meeting.

PRESIDENT'S OPENING REMARKS

(a) President Ballard presented the following message from H. R. H. The Duke of Edinburgh, an Honorary Member of the Institute:

"TO:

The Engineering Institute of Canada

Many congratulations on the 75th Anniversary of The Engineering Institute of Canada, I send you all my very best wishes for a successful Annual Meeting and for the next twenty-five years until your Centenary Celebrations.

Philip".

(b) The president extended a sincere welcome to those present. He reported that the E.I.C. has had an interesting and in some ways difficult year; and that this Annual Meeting would discuss some very important issues, one of these being Confederation.

(c) The President reported that a letter ballot for the election of Vice-Presidents of the Institute has been held in accordance with By-Law 43, and requested Mr. Roger Harvey, Chairman of the Committee of Scrutineers, and his committee, to canvass publicly the ballots so cast.

CONFIRMATION OF MINUTES

It was moved by Mr. J. J. Hanna, seconded by Mr. R. B. Chandler, and carried unanimously, that the minutes of the Seventy-Fifth Annual General Meeting of The Institute held in Vancouver, B.C. on Wednesday, June 1, 1961, be taken as read and adopted.

REPORT OF COUNCIL, REPORT OF FINANCE COMMITTEE, REPORT OF OFFICIAL AUDITORS, AND TREASURER'S REPORT

(a) The President stated that the Report of Council for the year 1961 was incorporated in the Annual Report of 1961, which was circulated to the membership in April, 1962 issue of The Engineering Journal.

It was moved by Mr. R. Harvey Self, seconded by Mr. H. A. Mullins, and carried unanimously, that the Annual Report of Council for the year 1961 be approved.

(b) Mr. G. N. Martin, Chairman of the Finance Committee, said that the report of the Finance Committee, which was contained in the Annual Report for 1961, was not a happy report, although the Finance Committee had worked hard to make it so. He explained how for many years the Institute had enjoyed a substantial revenue from its publications, but that this surplus position was now changed and that in order for the Institute to maintain the services which it is now performing it will be necessary to receive additional revenue from membership fees. He mentioned that substantial voluntary contributions have been received to date and stated that later in the year the membership would be asked to vote on a change in by-laws in connection with an increase in membership fees.

It was moved by Professor R. E. Chant, seconded by Brig. A. B. Connelly, and carried unanimously that the report of the Finance Committee for 1961 be adopted.

Dr. Ballard said that some of the members feel that no further services are necessary but, that if they were confronted with the day-to-day operation of the Institute they would be convinced otherwise. One of the first requirements which he felt was necessary was to maintain better communications with the membership and the Branches. It has become apparent that the present system of bringing councillors from Branches is not workable and the result is that very often whole areas of the country are not represented at Council meetings. He said that he was convinced that some method is necessary to finance attendance at Council meetings, possibly two per year, so that these important issues can be discussed.

He added that he also felt that better methods of publishing papers are needed, since the Institute is essentially a technical and learned society and at the present time it is not possible to publish all the worthwhile papers which are received. He said that methods are being adopted to reduce the costs of publication, and he felt that if the E.I.C. is to maintain its high technical standards it is necessary to not only publish the papers themselves, but also the discussion of important papers.

(c) In presenting the Treasurer's Report and the Report of the Official Auditors, the Treasurer, Mr. E. B. Jubien, noted that some of the figures had already been commented upon, and that 1961 had been a particularly trying year.

It was moved by Mr. H. A. Mullins, seconded by Col. A. Archavsky, and carried unanimously that the Treasurer's Report and the Report of the Official Auditors be adopted.

It was moved by Mr. H. A. Mullins, seconded by Col. A. Archavsky, and carried unanimously that the firm of Peat Marwick Mitchell & Company, Chartered Accountants be appointed the Official Auditors of the Engineering Institute of Canada for the year 1962.

REPORT OF COMMITTEE ON BRANCH OPERATIONS

Mr. F. L. Lawton, Chairman, Committee on Branch Operations, said that the report of the Committee to December 31, is contained in the 1961 Annual Report. Although the Committee was set up only a short while ago, the report indicates that it is making progress. The Activities of the Branches were analyzed on the basis of returns received, a report was compiled and some eighteen recommendations were made, which he believed were proving useful. The Committee, through its sub-committees on Model Branch By-Laws and Model Branch Accounts, was achieving practical success. Branch Achievement Awards are being made this year for the first time. He drew attention to an error which appeared in the final sentence of the printed report, which should read "There is increasing evidence this Committee, as constituted in 1960, is able to contribute materially to those activities of E.I.C. in which the Branches are most vitally concerned."

It was moved by Dr. J. B. Stirling, seconded by Mr. J. J. Hanna, and carried, that the amended report of the Committee on Branch Operations be adopted.

REPORT OF THE COMMITTEE ON MEMBERSHIP

Mr. E. D. Gray-Donald, Chairman of the Committee on Membership, stated that the report of his committe was also contained in the 1961 Annual Report. The final figure for membership at the end of 1961 was 22,601 and this figure now stands close to 23,500 a substantial increase in such a short period of time. He paid tribute to the many members of the Committee on Membership, with particular emphasis on the outstanding work which Miss Elsie MacGill of Toronto has been doing and is continuing to do in obtaining new members. He said that the obtaining of new members is a most important activity and that all members of the Institute should consider themselves members of the Committee on Membership.

It was moved by Mr. E. D. Gray-Donald, seconded by Mr. Huet Massue, and carried, that the report of the Committee on Membership be adopted.

REPORT OF THE COMMITTEE ON TECHNICAL OPERATIONS

In presenting the report of the Committee on Technical Operations its Chairman, Mr. S. Sillitoe, stated that the report had been written some time ago and that at that time there were nine active divisions. Since that time there are now twelve active divisions of C.T.O. and two more in process of formation. This is a good indication of the progress that has been made in the activities of C.T.O. and there is direct evidence of this progress in the technical program which has been planned for the Annual Meetings, which includes sixty-six papers and three symposia. There are also eight more regional technical conference planned. Mr. Sillitoe reported that on June 11th, the most successful C.T.O. meeting yet was held and that it is very encouraging to see the progress that is being made in the technical operations of the Institute. He paid tribute to the chairmen of the various technical divisions, who have given so much of their time and effort.

President Ballard thanked Mr. Sillitoe and his committee for the excellent work they have done.

It was moved by Mr. Sillitoe, seconded by Col. W. A. Capelle, and carried, that the report of the Committee on Technical Operations be adopted.

REPORTS OF OTHER COMMITTEES, REPORTS OF REPRESENTATIVES, REPORTS OF BRANCHES AND THE ONTARIO PROVINCIAL DIVISION.

(a) The President stated that the reports of other committees, reports of Representatives, reports of Branches and the Ontario Provincial Division were incorporated in the 1961 Annual Report.

(b) The General Secretary read a letter from Mr. H. Cimon regarding the work of the Life Members Committee.

After discussion, it was moved by Mr. E. A. Cross, seconded by Mr. R. Harvey Self, and carried, that Council be requested to investigate how the Life Members Committee is being managed, to make certain that the policies of that committee are in accordance with the overall policies of the Institute.

(c) Mr. R. N. Boyd, Chairman of the Library and House Committee, moved an amendment to the report of the Life Members Committee, to delete the words "at the request of the Library and House Committee" from the fourth paragraph of the printed report of the Life Members Committee. This was seconded by Mr. Hammerschmidt, and carried.

(d) It was moved by Professor A. C. Davidson, seconded by Mr. C. G. Southmayd, and carried, that the reports of other committees, reports of Representatives, and reports of Branches and the Ontario Provincial Division be adopted.

THE HARRY F. BENNETT EDUCATIONAL TRUST FUND

The general Secretary presented the report of the Board of Trustees of the Harry F. Bennett Educational Trust Fund, which was not received in time to be published in the Annual Report of Council.

Dr. Dick asked whether a statement of assets would be appended to the report. The General Secretary replied that the Auditors' report was in the hands of the trustees and would be added to the printed minutes of this meeting as they will appear in the Journal, for the information of the membership. (appendix "A").

It was moved by Mr. E. D. Gray-Donald, seconded by Dean H. Gaudefroy, and carried, that the report of the Board of Trustees of the Harry F. Bennett Educational Trust Fund be adopted.

NOMINATING COMMITTEE, 1962

President Ballard reported that the composition of the Nominating Committee for 1962 was listed on Page 13 of the Annual Report, with Mr. E. D. Gray-Donald of Montreal as Chairman. One member from each Branch has been appointed to serve on this Committee.

OTHER BUSINESS

(a) Annual Meeting of Council, June 10, 1962

President Ballard reported that the number of Vice-Presidents in Zone "C" had been increased on an interim from two to four; two being assigned to Montreal, one to the Eastern portion of Quebec, including Quebec City and the North Shore, and one to the territory between Montreal and the Eastern portion, including the Eastern Townships, St. Maurice Valley, and the North Shore. The number of Vice-Presidents in the Atlantic Provinces, Zone "D" had been increased from one to two, with the additional Vice-President being assigned to Newfoundland.

PROPOSED AMENDMENTS TO E.I.C. BY-LAWS

(a) President Ballard said that for some years it has been apparent that certain changes to the Institute By-Laws are necessary to bring them in line with current practice, as approved by Council. Accordingly, Council requested the Committee on By-Laws, with Mr. J. S. Waddington of Brockville as Chairman, and Messrs. Janitsch and Dolphin of Belleville and Kingston, members, to prepare appropriate amendments to the By-Laws, and to review amendments that had been proposed by the membership in accordance with the By-Laws. These proposals were approved by Council and were mailed to corporated members not less than 21 days before the Annual General Meeting, as required by Section 79 of the By-Laws.

These proposals are now before the membership for discussion; the members here present may propose an amendment or amendments thereto, and all proposals, together with such amendment or amendments as are approved by the Annual General Meeting, shall be printed on a letter ballot to be submitted to the corporate membership of the Institute. The General Secretary shall issue the letter ballot not later than two months after this annual general meeting. An affirmative vote of two-thirds of all valid ballots shall be necessary for the amendment or repeal of existing By-Laws or for the adoption of new By-Laws.

(b) Section 20—Entrance Fees

The present requirement that entrance fees be submitted with an application is rather awkward. Reference: Executive Committee Meeting August 18, 1961—Minute 61/595.

It is proposed that the first sentence of Section 20 be written as follows:

Present Wording:
The entrance fees, payable at the time of application for admission to the Institute shall be as follows:
Proposed Wording:
The entrance fees, payable at the time of admission to the Institute shall be as follows.

It was moved by Mr. W. M. Hogg and seconded by Mr. Self, and carried that this Annual General Meeting approves the amendment to Section 20, Entrance Fees, for submission by letter ballot to the corporate membership.

(c) Section 21—Annual Fees—Table of Fees

This matter has been under consideration for some time, and was included in the proposed amendments last year. Under Minute 61/678 of the Council Meeting on September 23, 1961, the Chairman of the Finance Committee reported that the membership had not accepted the proposal to increase fees. During the discussion, it was pointed out that Council could not better prepare the membership for this increase, because of the By-Law requirement for ballots to be mailed within 60 days of the Annual Meeting.

It was moved by Professor A. C. Davidson and seconded by Mr. R. Harvey Self that the Institute fees be increased to the proposed new rates given below: It is proposed that this section be written as follows:

Present Wording:

Montreal Branch Residents	All other Branch Residents Members	Branch Non-Residents and Non-Residents
$20.00	$18.00	$16.00
	Associate Members	
9.00	7.00	6.00
	Students	
2.00	2.00	2.00
	Affiliates	
21.00	19.00	17.00

Honorary Members shall be exempt from annual fees.

Proposed Wording:

All Branch Residents		Branch Non-Residents and Non-Residents
$24.00	Fellows	$22.00
24.00	Members	22.00
14.00	Associate Members	12.00
3.00	Students	3.00
25.00	Affiliates	23.00

Honorary Members shall be exempt from annual fees.

Mr. Gray-Donald questioned whether the proposed fees are adequate. Mr. Martin stated that, to the best knowledge of the present Finance Committee, it is believed that these fees are adequate, possibly for the next five years, taking into account normal growth of the membership and substantial increase in services.

Mr. Self said that he would like, on behalf of the Council, to urge everyone to go back to their branches and support this. He stated that Mr. Martin had given a very good report at the last meeting of Council in Toronto and at the Annual Meeting of Council on June 10th.

Dr. Porter inquired whether the addition in the fees takes into account the possibility that the Institute urgently requires a new Headquarters Building.

Mr. Martin replied that a fee of $24.00 does not take into account a new building for Headquarters. This is being studied by the Finance Committee at the present time but studies are not sufficiently advanced to report either to Council or to the annual meeting.

Dr. Ballard mentioned that for the information of those who had forgotten, the membership fees used to be $22.00 per annum. This amount included the subscription fee to the Journal, and when the advertising policy of the Journal was changed, the latter was distributed free to the membership, since it was expected that it would be self-supporting, and the overall fee was reduced accordingly. The new fee now being suggested is only $2.00 per annum more than that of a few years ago.

Mr. Gooch said that, as a Montreal member, he felt that he would be remiss in not proposing an amendment to the motion that would add the exception that in the case of Montreal members an additional $2.00 be added. Montreal members recognize that they have certain privileges and get certain additional advantages by membership in the Institute. They have had this differential in the past and feel that their privileges are going to be none the less in the future. He moved an amendment to the effect that Montreal members be charged an additional $2.00 for M.E.I.C. and A.M.E.I.C.

Mr. C. G. Kingsmill seconded this motion.

Mr. Hobbs asked on what basis the $2.00 differential for Montreal Branch members had been established. Mr. Gooch said that the differential could not be calculated exactly, but that this was the figure that had been used in the past. He felt that it was a reasonable figure, based on past experience.

Mr. Martin stated that in placing the revised fee schedule before Council, and which was approved by Council, he felt it was fair that the meeting should be aware of the thinking behind this. The present differential takes care of the use of the auditorium and the use of the Library. At the time the By-Law changes were proposed it was not known whether the Library service would be maintained as such. Furthermore, it has become apparent that members outside Montreal are making much more frequent use than they did of the Library in the past. Regarding the use of the Auditorium, most of this space has been taken over for administrative purposes, and the point has been reached when it will be necessary to tell the Branch that they cannot have the use of the Auditorium. For these reasons, it is felt that it would be preferable to have the same fees all across Canada.

Mr. Kingsmill appreciated Mr. Martin's remarks but wondered, if this is so, whether the rebates to the Montreal Branch would not increase accordingly.

Mr. Martin replied that 20% of the $2.00 per member would be returned to the Branch as a rebate and the Montreal Branch members might decide that they are not getting the additional services they have been paying for.

After further discussion, the amendment to the motion regarding an additional $2.00 for Montreal Branch members was defeated, 30 pro, the balance of those present con.

Dr. Ballard asked whether there was any further discussion on Section 21.

The motion to accept the amendment to Section 21 of the By-Laws was carried unanimously, that this Annual General Meeting approves the amendment to Section 21, Annual Fees—Table of Fees, for submission by letter ballot to the corporate membership.

Nomination and Election of Officers

(d) The procedure in the present By-Laws for the Nomination and Election of Officers is difficult to follow. A special committee appointed by Council studied the procedure and reported to the Executive Committee Meeting of August 18, 1951.

After approval by Council, these By-Law changes are based on the report of the Committee—Minute 61/768.

Section 37—Election of Nominating Committee—

Present Wording:
"The nomination of officers of the Institute shall be made by a Nominating Committee. The honorary Councillors shall be ex-officio members of this committee. The remaining members shall be elected annually as follows: Each branch shall appoint one member, and additional member appointed by the Council shall be chairman of the committee. The membership of the committee shall be announced at the Annual General Meeting. Vacancies in the Nominating Committee as announced at the Annual General Meeting shall be filled by Council from the nomination or nominations submitted by the branch in which the vacancies occur."

Proposed Wording:
"The nomination of officers of the Institute shall be made by a Nominating Committee composed of:

(A) A representative from each branch, elected annually by the branch.

(B) A representative from each zone appointed by Council from members of Council serving the final year of a tour of duty as a Councillor.

(C) Honorary Councillors.

Categories (B) and (C) shall be concerned only with Presidential nominees.

Annually, Council shall appoint a Committee member from Category (B) to act as Vice-Chairman of the Nominating Committee for the following year, even though he may not be a Councillor during his second year of office. Such appointments shall be on a zone-rotation basis.

The Membership of the Committee shall be announced at the Annual General Meeting.

Vacancies in the Nominating Committee as announced at the Annual General Meeting shall be filled by Council from the nomination or nominations submitted by the branch in which the vacancies occur."

It was moved by Mr. Edgar A. Cross, seconded by Mr. B. Monaghan and carried that this Annual General Meeting approves the amendment to Section 37—"Election of Nominating Committee", for submission by letter ballot to the corporate membership.

Section 38—Meetings of Nominating Committee

It was proposed to amend Section 38, as follows:

Present Wording:

"The Nominating Committee shall meet not later than the first of August to nominate officers for the ensuing year. Three members shall constitute a quorum, and members unable to be present may vote by letter."

Proposed Wording:

Delete.

It was moved by Mr. W. M. Hogg, seconded by Mr. S. Sillitoe, and carried that Section 38—"Meetings of Nominating Committee" be deleted from the By-Laws, for submission by letter ballot to the corporate membership.

Section 39—List of Nominees for Officers

It was proposed that Section 39 be written as follows:

Present Wording:

"The Nominating Committee shall prepare a list of nominees for officers, which shall contain the names of one or more nominees for each office to be filled, with the exception of that of president for which only one name may be submitted. A vice-president shall be elected by vote of the corporate members resident within the zone for which he is a candidate. One vice-president each shall be elected from Zones A and D and two vice-presidents each from Zones B and C. One of the vice-presidents for Zone C must be resident within twenty-five miles of the Headquarters of the Institute.

A councillor shall be elected by vote of the corporate members resident within the branch district for which he is a candidate. The list of nominees for officers shall be forwarded by the Nominating Committee to reach Headquarters not later than the fifteenth day of September, for presentation to Council at a meeting to be held not later than the thirtieth day of September, and should be accompanied by a letter of acceptance of nomination from each nominee.

The Council shall examine the list of nominees for officers submitted by the Nominating Committee. If the Council finds a nominee ineligible for the office which he is nominated, or should the consent in writing of a nominee to appear on the list of nominees for officers not be furnished before the first meeting of Council in October, or should any nominee after such consent withdraw his name, such name shall be deleted, and, if necessary, the Council shall substitute another name therefor. The words "Proposed by Nominating Committee" and "Proposed by Council" shall be printed conspicuously on the list of nominees for officers, to indicate the manner of nomination of all nominees."

Proposed Wording:

"The Nominating Committee shall prepare a list of nominees for officers, which shall contain the names of one or more nominees for each office to be filled, with the exception of that of president, for which only one name may be submitted.

A vice-president shall be elected by vote of the corporate members resident within the zone for which he is a candidate.

Two vice-presidents shall be elected from Zone A, three from Zone B, two from Zone C and one from Zone D. One of the vice-presidents for Zone C must be resident within twenty-five miles of the headquarters of the Institute.

A councillor shall be elected by vote of the corporate members resident within the branch district for which he is a candidate.

Before August 1st, the General Secretary shall preoare an initial letter to the members of the Nominating Committee, notifying them of the vacancies to be filled and nominations required.

Branch representatives shall submit, by September 30th, direct to the Chairman of the Nominating Committee, nominations for Vice-Presidents and Councillors, together with letters of acceptance.

Branch representatives shall submit, by September 15th, to their zone representative, nominations for President. Zone Representatives shall ensure that at least one, and preferably two or more, nominations for President (with biographies and branch affiliations), go forward from their zones, by October 15th, to the Chairman of the Nominating Committee.

The Chairman of the Nominating Committee shall immediately send a list of all Presidential nominees (with biographies and branch affiliations) to the members of the Nominating Committee in Categories (b) and (c) and, at the same time, establish the order in which the Presidential nominees should be approached. The Nominating Committee shall submit to Council for examination, the list of nominees for officers. If Council finds a nominee ineligible for the office for which he is nominated, or should the consent in writing of a nominee to appear on the list of nominations for officers not be furnished before the meeting of Council in December, or should any nominee, after such consent, withdraw his name, such name shall be deleted and, if necessary, Council shall substitute another name therefore. The words "Proposed by Nominating Committee' and "Proposed by Council" shall be printed conspicuously on the list of nominees for officers, to indicate the manner of nomination of all nominees."

Mr. Gray-Donald stated that, in view of the action of Council, Minute 62/236, increasing the number of Vice-Presidents in Zone C from two to four; two being assigned to Montreal, one to the Eastern portion of Quebec, including Quebec City and the North Shore, and one to the territory between Montreal and the Eastern portion, including the Eastern Townships, St. Maurice Valley, and the North Shore; and Minute 62/237, increasing number of vice-presidents in Zone D from one to two, the additional vice-presidents being assigned to Newfoundland, that Paragraph 2 section 39 should be amended accordingly.

It was moved by Mr. Gray-Donald, seconded by Mr. S. Sillitoe, and carried that Paragraph 2 of Section 39 be amended to read as follows:

"A vice-president shall be elected by vote of the corporate members resident within the zone for which he is a candidate. Two vice-presidents shall be elected from Zone A, three from Zone B, four from Zone C and two from Zone D. Two vice-presidents from Zone C must be resident within twenty-five miles of the headquarters of the Institute."

It was moved by Mr. H. A. Mullins, seconded by Mr. J. B. Delage, and carried that this annual General Meeting of Council approves the amendment to Section 39, as amended—"List of Nominees for Officers", for submission by letter ballot to the corporate membership.

Section 40—Publication of Nominations

It was proposed that Section 40 be written as follows:

Present Wording:

"Not later than the seventh day of November, the secretary shall mail to each corporate member of the Institute, the list of nominees for officers, as prepared by the Nominating Committee and the Council."

Proposed Wording:

"The list of nominees for officers shall be published in the Journal of the Institute not later than the January issue, preceding the Annual Meeting."

It was moved by Mr. Watt and seconded by Mr. J. J. Hanna that the amendment to Section 40 be approved.

It was moved by Mr. Murphy, seconded by Mr. Self, and carried that the report of the Nomination Committee be printed in the December issue of the Engineering Journal.

Mr. Hanna asked how it would be possible to mail the list of nominees to the membership by November 7th and have replies back in time for publication in the December issue of the Journal.

The General Secretary replied that the list of nominations published in the December issue are nominations from the Nominating Committee.

Mr. Cameron said that the amendment to Section 40 stated "A list of nominees for officers", not "a list of nominations of the nominating committee."

It was moved by Mr. Hanna, seconded by Col. Capelle, and carried, that Section 40 should state "The list of nominees for officers as submitted by the Nominating Committee and approved by Council shall be published . . . . ".

The original motion was carried and it was therefore resolved that the amendment to Section 40—"Publication of Nominations", as amended, be approved for submission by letter ballot to the corporate membership.

Section 41—Additional Nominations

It was proposed that Section 41 be written as follows:

Present Wording:

"Additional nominations for the list of nominees for officers signed by ten or more corporate members and accompanied by written acceptance of those nominated, if received by the general secretary on or before the first day of December, shall be accepted by the Council and shall be placed on the officers' ballot. The words 'Special Nomination' shall be printed conspicuously near such names, and the names of the members making such nominations shall be printed on some part of the officers' ballot."

Proposed Wording:

"Additional nominations for the list of nominees for officers may be accepted from corporate members prior to the first day of March. Such additional nominations shall be signed by ten or more corporate members, and be accompanied by the written acceptance of those nominated. These additional nominations shall be sent direct to the General Secretary, considered by Council, and, if accepted, placed on the officers ballot. The words 'Special Nomination' shall be printed conspicuously near such names, and the names of members making such nominations shall be printed on some part of the officers' ballot."

It was moved by Col. A. Archavsky and seconded by Mr. R. N. Boyd that this amendment be approved.

Mr. E. D. Gray-Donald stated that March 1st was too late a deadline for additional nominations, and that he felt it would be preferable to change this to February 1st.

It was moved by Mr. Gray-Donald and seconded by Professor R. E. Chant that the deadline for additional nominations be amended to February 1st.

Mr. Neilson asked what were the reasons behind this amendment.

The General Secretary replied that the thinking of the committee was that if the membership are notified of nominations not later than the 7th of November, the date of December 1st did not allow sufficient time for additional nominations.

Mr. Gray-Donald said that since Section 40 calls for publication of the report of the Nominating Committee in the December issue of the Engineering Journal, he felt that this amendment to Section 41 had some dependence upon Section 40.

The amendment to the motion was carried, with ten opposing votes.

Dr. Tait drew attention to the clause which states that "Such additional nominations shall be signed by ten or more corporate members, and be accompanied by the written acceptance of those nominated. These additional nominations shall be sent directly to the General Secretary, considered by Council, and, if accepted, placed on the officers' ballot." He said this change would permit Council to turn down a nomination, even though it was signed by ten corporate members.

Dr. Ballard said that this was put in to provide for the elimination of members who are not in good standing.

The original motion was carried, with four votes in opposition, and it was therefore resolved that the amendment to Section 41—"Additional Nominations" be approved, as amended, for submission by letter ballot to the corporate membership.

Section 42—Officers' Ballot

It was proposed that Section 41, paragraph 3, be amended as follows:

Present Wording:

"In the event of only one name being submitted for any office prior to December 1st, Council shall declare that nominee elected by acclamation."

Proposed Wording:

"In the event of only one name being submitted for any office prior to the first day of March, Council shall declare that nominee elected by acclamation."

It was moved by Mr. J. J. Hanna and seconded by Mr. Gray-Donald that the amendment to Section 42 be approved.

Mr. Richmond questioned whether there were any difficulties involved in the date of March 1st and whether it would not be preferable to change this to February 1st.

The General Secretary replied that from the point of view of administration and operation, February 1st would be preferable. March 1st is rather late as far as printing is concerned, but Section 42 reads "mailed at least 30 days before the Annual General Meeting", which would leave time enough before the Annual General Meeting.

It was moved by Mr. E. A. Cross, seconded by Mr. Murphy, and carried that the amendment to Section 42 be amended to read February 1st.

The original motion was carried, and it was therefore resolved that Section 42—"Officers' Ballot", as amended, be approved by this Annual General Meeting for submission by letter ballot to the corporate membership.

There was some discussion regarding conflicting dates in Sections 39, 40, 41, and 42 as amended, and it was moved by Mr. R. H. Self, seconded by Mr. W. M. Hogg, and carried that this Annual General Meeting approve these dates in principle only and that the problem of the exact dates be left to the Executive Committee of the Institute to decide prior to mailing the ballot to the membership.

(e) Section 45—Appointment of General Secretary, Treasurer and Committees

The membership of Council is so large (91 members) as to be difficult to assemble and slow in executive action. Rather than disturb the function of the Council in providing a means for communication both ways between each branch and Council, while at the same time speeding up the handling of many items of Institute business, an Executive Committee of Council has been in operation on a trial basis since the formation of the 1960 Council. This action was taken by resolution of Council. Minute 61/780 requested the By-Laws Committee to prepare appropriate amendments to provide for appointment of the Executive Committee along the lines established during the trial period.

It was proposed that Section 45 be written as follows:

Present Wording:

"The Council shall meet within seven days after its election and shall then appoint the general secretary, the treasurer, and the following standing committees:

A Finance Committee of five members, including the treasurer.

The Treasurer shall be ex-officio vice-chairman of the Finance Committee.

A Library and House Committee of five members.

A Committee on Technical Operations of at least six members.

A Publication Committee of five members.

A Legislation Committee of three members.

An Admissions Committee of at least five members, three to constitute a quorum.

The chairman of each standing committee shall be a member of the Council.

Standing Committees shall perform their duties under the supervision of the Council and shall report to the Council."

Proposed Wording:

"There shall be an Executive Committee of the Council which shall be composed of the President, the Vice-Presidents, the Immediate Past-President, the Treassurer, and the Chairman of such Standing Committees as shall be determined from time to time by Council. Five members of the Executive Committee shall constitute a quorum. Members of Council not included above are invited to attend meetings of the Executive Committee and to offer opinions, but will not vote. The Executive Committee shall meet at least seven times during the Institute's year.

The Council shall meet within seven days after its election and shall then appoint the general secretary, the treasurer, and the following standing committees:

A Finance Committee of five members including the treasurer. The treasurer shall be ex-officio vice-chairman of the Finance Committee.

A Library and House Committee of five members.

A Committee on Technical Operations of at least six members.

A Publications Committee of five members.

A Legislation Committee of at least five members.

An Admissions Committee of at least five members, three to constitute a quorum.

A Committee on Branch Operation of at least six members.

The Chairman of each standing committee shall be ex-officio a member of the Council.

Standing Committees shall perform their duties under the supervision of the Council and shall report to the Council."

It was moved by Mr. E. A. Cross, seconded by Mr. R. B. Chandler, and carried that this Annual General Meeting approves the amendment to Section 45—"Appointment of General Secretary, Treasurer and Committees" for submission by letter ballot to the corporate membership.

(f) Section 55—Meeting of Council

With the appointment of the Executive Committee, it is not necessary for the Council to meet as frequently as was the former practice.

It was proposed that Section 55 be written as follows:

Present Wording:

"Council shall meet at least once every two months, from October to May. Additional meetings that may be deemed necessary to conduct properly the business of the Institute shall be held at the call of the president. Five members shall constitute a quorum.

Proposed Wording:

"Council shall meet at least three times during the Institute's year to conduct such business as may come before it, and to review the actions of the Executive Committee.

Ordinary meetings of Council shall be held immediately before the Annual General Meeting, immediately after the Annual General Meeting, and on another date during the year, at the call of the President.

Extraordinary meetings may be held at any time at the call of the President, or on the written request of ten councillors addressed to the General Secretary. He shall give seven days' notice, and shall arrange that the notice be accompanied by an agenda and necessary documentation. Five members shll constitute a quorum."

It was moved by Mr. R. H. Self, and seconded by Dr. Tupper that the amendments to Section 55 be approved.

It was moved by Professor Davidson and seconded by Mr. Boyd that Council should meet at least quarterly.

After discussion the motion to amend the amendment was defeated, 26 pro, the balance of those in attendance con.

The original motion was carried with no dissenting votes and it was therefore resolved that this Annual General Meeting approves the amendment to Section 55—"Meetings of Council" for submission by letter ballot to the corporate membership.

(g) Section 79—New By-Laws—Amendments—Repeal

The present By-Law does not allow time for explanation, through branch meetings, of the circumstances and background of letter ballots. Minutes 61/678 and 61/679—Council Meeting of September 23, 1961.

It was proposed that Section 79, Paragraph 2, second sentence, be written as follows:

Present Wording:
"The general secretary shall issue the letter ballot not later than two months after the Annual General Meeting."
Proposed Wording:
"The General Secretary shall issue the letter ballot not later than six months after the Annual General Meeting."

It was moved by Mr. Gray-Donald, seconded by Mr. Murphy, and carried with no dissenting votes, that this Annual General Meeting approves the amendment to Section 79—"New By-Laws—Amendments—Repeal" for submission by letter ballot to the corporate membership.

(h) Discussion Re Ballot for Increase in Fees

Further to the discussion that took place on the proposed amendment to Section 21 of the By-Laws with regard to the increase in membership fees, concern was expressed regarding the timing of the ballot, since it was felt that the two month requirement for the ballot would not leave sufficient time for discussion with the Branches.

It was moved by Mr. R. H. Self and seconded by Col. W. A. Capelle, that in this particular group of by-law changes the ballot be delayed until October 1, 1962.

After considerable discussion, during which many members expressed the desire to hold the ballot on by-law amendments in the fall of the year, rather than within the sixty days after the annual general meeting, as prescribed by the By-Law, it was resolved, with five dissenting votes, that subject to it being found legal, the Executive Committee be instructed to conduct the required ballot of the membership regarding the proposed amendments to the by-laws, by October 1, 1962.

HONORS, MEDALS AND PRIZES

The President reported that the Council of the Institute had unanimously voted that certain Honours, Awards and Medals be bestowed by the Institute as follows:

HONORARY MEMBERSHIP
Robert S. Eadie
John Jeffery Hanna
Professor Thomas Richardson Loudon
Dr. E. W. R. Steacie
Dr. Donald McGregor Stephens

JULIAN C. SMITH MEDAL, 1961
Thomas Wardrope Eadie
Frederic Hatheway Peters

THE GZOWSKI MEDAL, 1961
Ernest Francois Pariset
Mr. Rene Hausser

THE LEONARD MEDAL, 1961
T. W. Wlodek

THE PLUMMER MEDAL, 1961
Donald S. Scott

THE DUGGAN MEDAL AND PRIZE, 1961
Prof. A. Hrennikoff

THE R. A. ROSS MEDAL, 1961
Dr. R. C. Langille

THE ROBERT W. ANGUS MEDAL, 1961
John Young

SIR GEORGE NELSON AWARD, 1961
K. H. Williamson

CANADIAN LUMBERMEN'S ASSOCIATION PRIZE, 1961
B. Madsen

THE ERNEST MARCEAU PRIZE
Guy Laberge

REPORT ON ELECTION OF NEW OFFICERS

Report:
The President said that a new President, and the appropriate number of Councillors were elected at the September 23 and October 28, 1962 meetings of Council in accordance with the By-Laws, as follows:

PRESIDENT, 1962-63—
Mr. F. L. Lawton, M.E.I.C.

COUNCILLORS
Elected for three years, 1962-65

Montreal	Marc Benoit
	Redmond Kane
	H. A. Mullins
Ottawa	G. B. Williams
Toronto	W. L. Hutchinson

Elected for two years, 1962-64

Calgary	F. L. Perry
Cape Breton	Vincent Palmer
Cornwall	B. T. Yates
Edmonton	A. Sandilands
Halifax	H. A. Marshall
Hamilton	W. A. Wheten
Huronia	F. A. Alport
Kitchener	J. Runge
Lethbridge	R. D. Hall
Moncton	W. M. Steeves
Niagara Peninsula	A. G. Asplin
Peterborough	D. A. Lamont
Quebec	P. A. Dupuis
Northern New Brunswick	No nominee
Northern Nova Scotia	No nominee
Sarnia	H. V. Page
Saskatchewan	R. Ludwig
Sault Ste. Marie	W. M. Hogg
Vancouver	J. H. Swerdfeger
Winnipeg	L. A. Bateman

The President introduced Mr. F. L. Lawton, of Montreal, the Institute's new President for 1962-63 to the meeting.

Mr. Lawton said he was sure he could speak for the incoming officers and the members of Council in expressing their appreciation of the confidence which has been placed in them. They can foresee an extremely heavy responsibility before them during the ensuing year and realize they will have very serious decisions to make. He said they would endeavour to meet their responsibilities to the best of their ability and he knew they could count on the support of the membership. He said they would do everything they could to ensure that the Institute continues to expand and improve.

CONFEDERATION

(a) Dr. Ballard reported that during the past year the Executive Committee of the Institute held several meetings with the Executive Committee of the Canadian Council of Professional Engineers. Both of these groups have suggested certain modifications regarding the Final Report of the Engineers Confederation Commission. Several provincial associations have gone on record as being in favour of the adoption of the report, but these do not include the three more populous provinces.

The E.I.C. and C.C.P.E. have not been able to come to an agreement, partly because the C.C.P.E., through no fault of its own had been unable to speak for all of its constituent bodies. Consequently, decisions had to be delayed until the conclusion of the annual meeting of C.C.P.E., held May 9, 10, 11, 1962.

(b) Dr. Ballard called upon Mr. Antenbring to summarize the present situation regarding Confederation.

Mr. Antenbring said that it would be difficult to summarize in a few minutes all that has transpired during the past year. Following the annual meeting of C.C.P.E., a joint meeting was held in Montreal on Saturday, June 9th with attendance limited to four representatives of E.I.C. and four of C.C.P.E.

This meeting was the culmination of several joint meetings which have been held since the 1961 annual general meeting of the Institute. The first of these meetings was held in Ottawa on July 13, 1961 at which it was proposed that C.C.P.E. and E.I.C. would study the Report of the Engineers Confederation Commission and suggest any change they thought fit.

Meanwhile, throughout the country interest was created and many discussions were held.

A further joint meeting was held in Montreal on December 15, 1961, to discuss any major points of difference. Little was accomplished because nothing was brought forward by C.C.P.E. in the way of concrete proposals, C.C.P.E. being unable to speak for its constituent bodies at that time.

At the joint meeting held on June 9, the representative of the C.C.P.E. introduced definite proposals for discussion. On this basis and with a friendly attitude, two groups tried to find some common ground for agreement. Some of the proposals presented by C.C.P.E. with which the E.I.C. was basically in disagreement were:

1. Under the new arrangement, branches of the Institute would come under the jurisdiction of the provincial associations.

2. Dues—Figures show that the new registration could not operate on the proposed fees of $12.50. A closer estimate would be $18.00 C.C.P.E. felt that members of the provincial associations would not agree to more than $10.00 per year in addition to the present association fee.

3. The funds which the E.I.C. would have to contribute to the organization would probably be expended in about a year, and the basic agreement would be on the basis of three years.

4. There was a strong feeling on the part of several of the provincial associations that there should be no compulsion for their members to join C.I.PE. However, the Commission report states that E.I.C. members must join a provincial association to be eligible for membership in the C.I.P.E.

This was the type of subject which was discussed at the meeting and no agreement was reached on any of them. This is probably because basically, the two organizations are vastly different, with different objectives, organization and administration.

The result of the meeting was that both bodies came to the conclusion that further negotiations were pointless and that the time had come to obtain the opinion of their memberships. It was agreed by the representatives of C.C.P.E. and the E.I.C. to recommend to their Councils that a letter ballot regarding the acceptability of the Final Report of the Engineers Confederation Commission be taken of their respective memberships, at the same time. Accompanying the letter ballot will be a statement of "pros and cons" regarding it, plus a statement of the opinion of Council. This will not be a joint statement, and each Council is free to prepare its own statement independently.

This action was approved at the Annual Meeting of Council held on June 10, 1962.

(c) It was moved by Mr. Antenbring, seconded by Mr. R. Harvey Self, and carried unanimously that this Annual General Meeting of the Engineering Institute of Canada authorize the Council of the E.I.C. or the Executive Committee of Council to proceed to ballot the membership regarding the Final Report of The Engineers Confederation Commission as published in the "Engineering Journal", September, 1961. The ballot to be mailed to all members at the appropriate time to comply with the wishes of both E.I.C. and C.C.P.E. namely, that the memberships of both bodies be balloted at the same time. The foregoing is subject to all of the constituent associations and corporation of the C.C.P.E. agreeing to hold such a ballot.

(d) It was further resolved that the necessary explanatory note be included with the ballot, bringing to the attention of the members the important issues to be considered, all in accordance with usual E.I.C. practice, and setting forth Council's opinion of the report.

VOTE OF THANKS

It was moved by Past-President V. A. McKillop, seconded by Mr. A. E. Cross, and carried with acclamation, that a hearty vote of thanks be accorded to the retiring President, Vice-Presidents and Members of Council in appreciation of the work they have done for the Institute during the past year.

ANNOUNCEMENTS AND RESULT OF OFFICERS' BALLOT

(a) Dr. Ballard called upon Mr. Roger Harvey, Chairman of the Committee of Scrutineers, to report on the canvass of the officers' Ballot. On receipt of the report, the President declared that the following are elected Vice-Presidents of the Institute for 1962-64:

Zone "A"	—	**J. B. Mantle, Saskatoon, Sask.**
Zone "B"	—	**George Humphries, London, Ontario**
		J. S. Waddington, Brockville, Ont.
Zone "C"	—	**Gaetan Cote, Sherbrooke, Que.**
		Georges Demers, Quebec, Que.
		J. J. Rowan, Montreal, Que.
Zone "D"	—	**S. Carew, St. John's, Nfld.**

(b) It was moved by C. G. Southmayd, seconded by Mr. R. N. Boyd, and carried that the ballots cast in the election of Vice-Presidents for 1962-64 be destroyed.

MOTION OF ADJOURNMENT

It was moved by Col. W. A. Capelle, seconded by Brig. A. B. Connely, and carried, that the Seventy-Sixth Annual General Meeting of the Engineering Institute of Canada be adjourned.

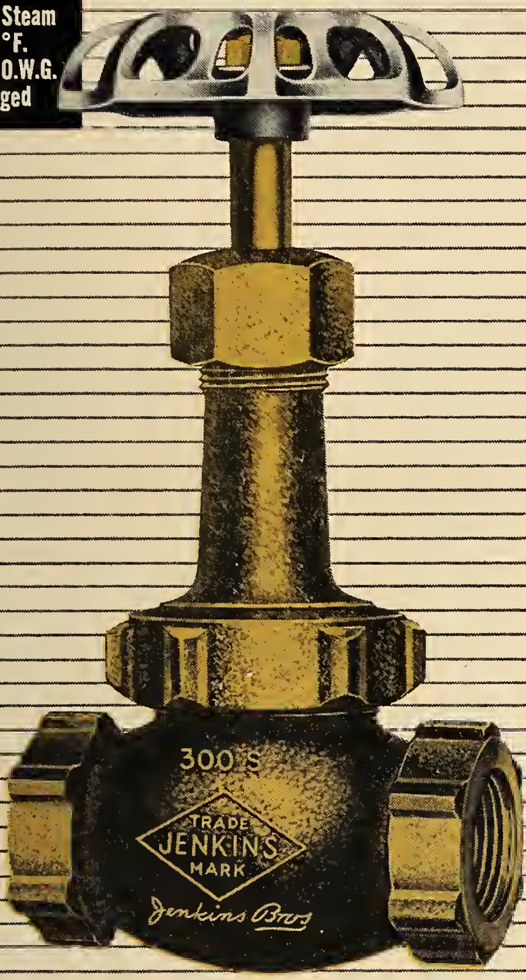
The meeting adjourned at 12:00 noon.

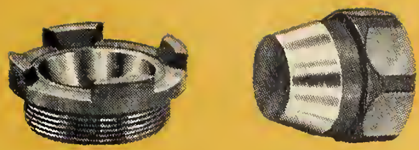
B. G. BALLARD, HON. M.E.I.C.
President

GARNET T. PAGE, M.E.I.C.
General Secretary

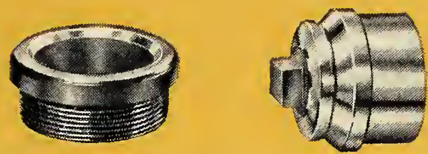
300
psi
STEAM
550°F.
600 lb. O.W.G.
Screwed

300 lb. Steam
550°F.
500 lb. O.W.G.
Flanged





PLUG DISC. Recommended for the most severe services where close throttling is necessary and lasting tightness is essential. Plug disc and seat are made from nickel alloy or 500 Brinnell stainless steel as specified. Offers greatest resistance to galling, cutting, abrasion, and corrosion. Seat rings and discs may be reground or renewed as required.



BEVEL DISC. Made of bronze or nickel alloy for specific services. Accurate relationship of disc and seat assures continuous tightness under severe conditions and frequent operation. Can be reground without removing valve from the line. Discs and seat rings are renewable.

Jenkins improved 300 lb. valves lead a long and active life

Wear resistance of Jenkins 300 lb. bronze globe and angle valves now surpasses even previous levels. The elongated bonnet increases spindle engagement and so produces less stress. The spindle threads themselves are finer to allow closer flow-control, and the deepened packing box provides a tighter seal with less friction on the spindle. These refinements mean a longer, more active life—even under the most adverse conditions—and close control of steam and other fluids.

To meet the needs of any installation, Jenkins produces a full range of these 300 lb. valves with full port bevel seat or throttling type plug seat, flanged or threaded ends, and bronze, nickel alloy or 500 Brinnell stainless steel seating combinations. Ask your Jenkins representative for complete specifications on Jenkins 300 lb. bronze valves. Jenkins Bros., Limited, Lachine, Que.

SOLD THROUGH LEADING DISTRIBUTORS EVERYWHERE

JENKINS VALVES

LOOK FOR THE JENKINS DIAMOND

TRADE JENKINS MARK

Jenkins Bros

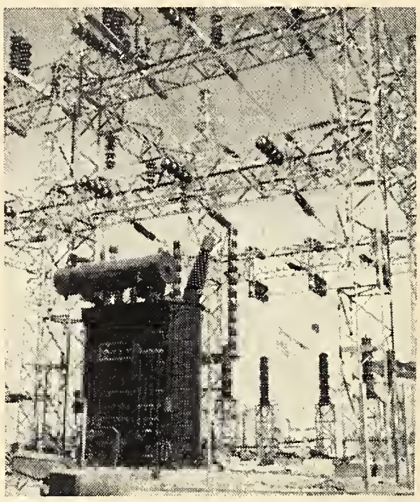
Canadian Developments

POWER IN CANADA

During 1961 Canada once again increased its capability to produce electric power, but the increase was the smallest in recent years. The increase was 248,000 kw. to 22,628,000 kw. This is only 1.1 per cent.

These figures came from the Eighth Annual Electric Power Survey of Capability and Load conducted by the Dominion Bureau of Statistics and include only producers which generate 10 million kwh. or more per year.

The 1961 increase was small, and the five-year forcast to 1965 is only about 63 per cent of the compound growth rate between 1951 and 1960. The forecast years 1961-65 indicate a compound growth rate of 5.76 per cent compared with 9.2 per cent for 1951-60.



Switch yard installation at Powell River

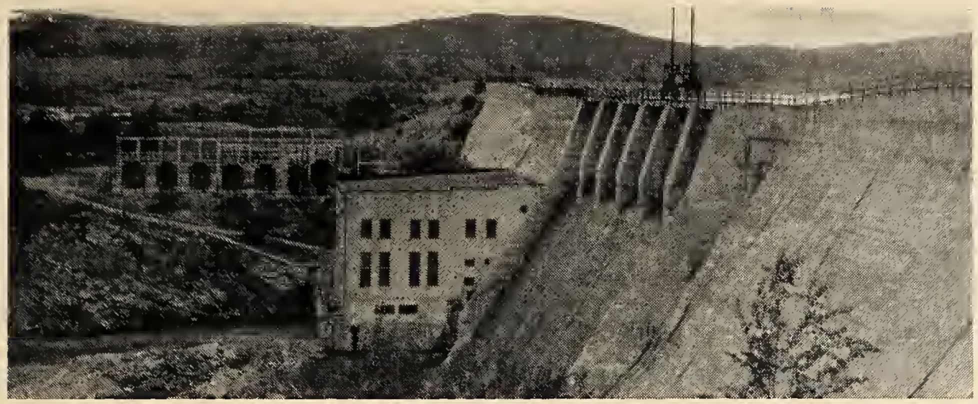
Thermal capability is expected to grow at the yearly rate of 14.5 per cent in the forecast period compared with 17.1 per cent in the previous period. Hydroelectric capability is expected to increase at 3.3 per cent per year compared with 8 per cent in the previous 10 years. Most of the thermal increase will be in steam plants, a small growth in gas turbines, while internal combustion plants will be virtually unchanged.

The first nuclear capability is forecast for 1965 although this may be postponed due to construction delays, or bringing the plant into line because of its pioneering nature. The nuclear capability does not include the 20,000 kw. plant at Rolphton, Ont. This is an experimental plant and is not considered part of capability.

ELECTRIC POWER AVAILABLE[1], BY PROVINCES

monthly averages or months	*Canada*	*Nfld.*	*P.E.I.*	*N.S.*	*N.B.*	*Que.*	*Ont.*	*Man.*	*Sask.*	*Alta.*	*B.C.*
	million kilowatt hours										
1960	*9,076*	116	7	143	139	3,658	3,082	379	139	288	1,111
1961	*9,203*	113	7	148	149	3,630	3,185	397	154	316	1,087
1960 J	*9,508*	123	7	152	143	3,734	3,281	429	152	311	1,163
F	*9,110*	120	6	142	135	3,640	3,132	400	140	290	1,093
M	*9,725*	127	7	153	143	3,904	3,326	422	146	305	1,180
A	*8,987*	114	6	140	134	3,682	3,044	377	127	267	1,081
M	*8,858*	116	6	136	139	3,550	3,059	352	127	267	1,094
J	*8,599*	111	6	132	140	3,485	2,936	337	122	264	1,053
J	*8,422*	111	6	129	129	3,474	2,816	319	122	259	1,042
A	*8,708*	115	6	137	133	3,603	2,903	335	133	270	1,058
S	*8,824*	112	6	136	131	3,580	2,938	418	133	278	1,077
O	*9,206*	118	7	146	137	3,767	3,077	361	140	291	1,146
N	*9,275*	116	7	153	155	3,686	3,145	367	154	311	1,165
D	*9,686*	112	8	158	154	3,793	3,326	428	172	337	1,183
1961 J	*9,808*	117	8	157	152	3,809	3,367	452	172	334	1,224
F	*8,891*	104	7	150	129	3,520	3,022	382	148	303	1,111
M	*9,668*	113	7	154	142	3,861	3,267	401	155	319	1,232
A	*9,087*	107	7	144	139	3,646	3,097	374	141	289	1,128
M	*9,297*	114	7	145	145	3,712	3,166	397	144	297	1,155
J	*8,586*	112	6	138	143	3,354	3,053	361	137	292	974
J	*8,313*	108	7	134	146	3,394	2,946	350	142	279	791
A	*8,615*	124	7	137	146	3,514	3,030	370	149	297	826
S	*8,772*	104	7	145	152	3,477	3,103	376	150	308	935
O	*9,543*	113	8	156	164	3,714	3,282	403	155	332	1,199
N	*9,713*	119	9	156	159	3,717	3,374	419	165	348	1,229
D	*10,139*	121	9	159	169	3,846	3,516	473	195	389	1,243
1962 J	*10,428*$_r$	122	9	168	166	3,964	3,628	483	197	387	1,283$_r$
F	*9,510*$_r$	120	8	152	149	3,651	3,304	427	177	351	1,152$_r$
M	*10,156*$_r$	133	8	165	165	3,900	3,521	440	180	368	1,257$_r$
A	*9,472*	116	8	153	152	3,685	3,284	408	148	312	1,191
M	*9,727*	136	7	160	161	3,804	3,329	427	157	332	1,197

[1]Total net generation less net exports. Source: Electric Power Statistics, (57-001), D.B.S.



Ghost Dam on Bow River

The forecast of generating capacity for 1961 was 367,000 kw. higher than was achieved. Reasons for this included the fact that 65,000 kw. thermal capacity was out of service at the time of the survey, and that there was a delay until 1962-64 in the completion of some plants. Ontario, Manitoba and Alberta were significantly below the forecast, while British Columbia exceeded it.

The largest absolute growth in generating capability for the forecast years is indicated for Ontario (2,135,000 kw.), Quebec (1,616,000 kw.), British Columbia (582,000 kw.), and Alberta (451,000 kw.). Whereas Quebec will meet most of the increased generating capability by adding more than 1,300,000 kw. in hydro capability and 200,000 kw. thermal, Ontario plans to increase its capability by adding 1,750,000 thermal, including 200,000 kw. nuclear, and only 385,000 kw. hydro. British Columbia plans to add 466,000 kw. thermal and 110,000 kw. hydro.

Firm power peak loads have not shown the same change in rate of growth as generating capability. In the 1950's the growth rate of firm power peak load in Canada was 7.5 per cent. This compares with a forecast rate of growth of 6.2 per cent.

As a result the indicated reserve is expected to decline in 1963 and 1964 from the 1962 total of 4,551,000 kw., then rise to 4,780,000 kw. in 1965. The indicated reserve is forecast to decline to 15.2 per cent in 1964 and rise in 1965 to 20.3 per cent.

Firm energy requirements increased 2.7 per cent for 1961 to 105,076,000,000 kwh. compared with a growth of 7.3 per cent in the previous 10-year period, and a forecast growth rate of 6.6 per cent for the 1961-65 period. All provinces except British Columbia shared in the current increase. The forecast for firm energy requirements made last year was some 2,500 million kwh. higher than was actually attained.

At the same time firm energy requirements were increasing, there was a reduction in the level of net exports (exports minus imports) to the United States and lower deliveries of secondary energy. This combined with a long shutdown of the Kitimat plant of the Aluminum Company of Canada Limited in British Columbia, and changed hydraulic conditions in certain parts of the country caused a slight reduction in net generation to 113,271,000,000 kwh.—the first decline since 1947.

TOTAL ELECTRIC POWER

monthly averages or months	*net generation*					*net exports*[3]	*available*[4]		
	hydraulic[1]	*thermal*[1]	*total*[1]	*utilities*[2]	*industries*[2]		*total*	*primary*	*secondary*[5]
	million kilowatt hours								
1960	8,814	689	*9,503*	7,415	2,088	427	9,076	8,471	605
1961	8,639	796	*9,435*	4,422	2,013	232	9,203	8,709	494
1960 F	8,790	654	*9,444*	7,401	2,043	334	9,110	8,410	700
M	9,320	752	*10,071*	7,821	2,250	346	9,725	8,961	765
A	8,811	600	*9,411*	7,296	2,115	424	8,987	8,287	700
M	8,765	603	*9,369*	7,392	1,977	510	8,858	8,275	584
J	8,557	578	*9,135*	7,165	1,970	536	8,599	8,027	572
J	8,477	579	*9,057*	7,047	2,009	635	8,422	7,882	540
A	8,643	683	*9,326*	7,212	2,115	618	8,708	8,172	536
S	8,521	735	*9,256*	7,165	2,091	432	8,824	8,297	527
O	8,784	794	*9,578*	7,423	2,154	371	9,206	8,636	571
N	8,812	778	*9,591*	7,475	2,116	216	9,275	8,751	524
D	9,096	818	*9,914*	7,758	2,156	224	9,686	9,138	548
1961 J	9,096	893	*9,989*	7,810	2,179	181	9,808	9,243	565
F	8,156	861	*9,018*	7,002	2,016	126	8,891	8,430	461
M	9,030	837	*9,867*	7,599	2,269	199	9,668	9,071	597
A	8,732	687	*9,419*	7,318	2,101	332	9,087	8,522	565
M	8,988	701	*9,689*	7,604	2,085	393	9,297	8,673	624
J	8,276	630	*8,906*	7,021	1,885	320	8,586	8,228	358
J	7,978	665	*8,643*	6,941	1,701	330	8,313	7,888	425
A	8,066	767	*8,833*	7,077	1,755	217	8,615	8,214	401
S	8,169	824	*8,993*	7,203	1,790	221	8,772	8,341	431
O	8,882	855	*9,737*	7,645	2,092	194	9,543	9,058	485
N	8,949	897	*9,846*	7,737	2,110	133	9,713	9,233	479
D	9,349	929	*10,279*	8,102	2,176	139	10,139	9,607	533
1962 J	9,424$_r$	1,169	*10,593*$_r$	8,355	2,238$_r$	166	10,428$_r$	9,877$_r$	551
F	8,607$_r$	1,013	*9,620*$_r$	7,573	2,047$_r$	112	9,510$_r$	8,964$_r$	545
M	9,307$_r$	992	*10,299*$_r$	8,099	2,201$_r$	143	10,156$_r$	9,570$_r$	586
A	8,935	743	*9,678*	7,625	2,053	206	9,472	8,921	552
M	9,250	749	*9,999*	8,011	1,988	272	9,727	9,153	573

[1]These totals include all generating agencies producing over ten million klowatt hours per year. [2]These columns include all generating utilities and generating industries respectively, producing over ten million kilowatt hours per year. [3]Less imports. [4]Total net generation less net exports. [5]Mainly the amount used in electric boilers. Sources: Electric Power Statistics, (57-001), D.B.S.

Personals

J. C. Waddell has been appointed Vice President of Administration at Liquid Carbonic Canadian Limited. **C. Berntson** has been named Vice President in charge of sales, CO-2 Division with the company. Both men will have headquarters at the company's Montreal office.

J. C. Waddell

C. Berntson

E. G. Townsend has been appointed Manager, Utilities and Industrial Sales for the Quebec District, at Canadian General Electric Company. Mr. Townsend has been associated with the company since 1927. **A. H. Du Chene** has been named Manager, Construction and General Supply Sales. For the past nine years Mr. Du Chene has been Manager of the Wholesale Department's Branch office in Quebec City. **P. E. St. George** has been appointed Manager of the Quebec Branch office.

Paul J. Hutchison has been appointed sales supervisor for the Toronto Branch Industrial Products Group of Honeywell Controls Limited. Mr. Hutchison will be responsible for the co-ordination of accounts, marketing programs and sales training. Other appointments at Honeywell includes those of **Harvey E. Allan** who will be responsible for industrial instrument sales in Toronto, and **Douglas W. Burns** who will handle sales in the Guelph, Hamilton, Kitchener areas. **John Kent** will be responsible for industrial sales to the pulp and paper industry in the Ottawa Valley, Montreal and New Brunswick regions.

Harvey E. Douglas, A.M.E.I.C. (N.S.T.C. '60) has joined the sales staff of the Industrial Products Group, Honeywell Controls Limited, Toronto Office.

William D. Garrick has been appointed General Manager of Dominion Bridge's Alberta Branch. Mr. Garrick will assume responsibility of the company's plants at Edmonton and Calgary, and will have headquarters in Edmonton.

R. J. Marner has been appointed apparatus sales engineer at Canadian General Electric's Edmonton offices. He will be responsible for the company's apparatus products throughout northern Alberta and the Northwest Territories. **H. T. Rappel** was appointed apparatus sales engineer for Saskatchewan with head offices in Regina.

L. W. Grover of Underwood McLellan and Associates has been appointed Vice President and Area General Manager for Alberta. He will have offices in Calgary.

L. W. Grover

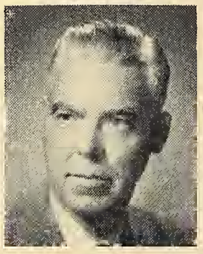
G. R. Raisbeck

G. R. Raisbeck has been appointed manager of the Westinghouse Wholesale Division. Mr. Raisbeck has been general products sales manager for the division since 1961.

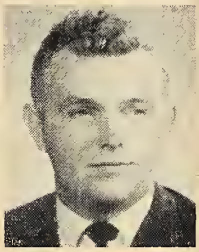
Roland G. White, M.E.I.C. (Queen's '54) has been named Toronto Manager of Tunnicliff Consultants Limited. Mr. White has had several years experience with contractors in eastern Canada as Project Manager Engineer on the St. Lawrence Seaway, and highway construction.

D. C. Allen has been appointed Plant Superintendent, Electrolytic Plant, Zinc Department, Metallurgical Division of the Consolidated Mining and Smelting Company at Trail, B.C.

Norman J. Sweetlove has been appointed Sales Manager of Retor Developments Ltd., Galt, Ont. Mr. Sweetlove will be responsible for Canadian sales of the Mimik hydraulic machine tool tracer, and will co-ordinate sales for the company in the United States, Britain and West Germany.



N. J. Sweetlove



Robert J. Sebert

Robert J. Sebert has been appointed manager of the recently established drinking fountain systems division of Wade In Canada Plumbing Specialties Ltd. Previous to his recent appointment, Mr. Sebert had been responsible for the operation of the company's Montreal office.

Kalju Ojala has been named municipal engineer with McNamara Engineering Limited. Mr. Ojala has several years experience in the design of municipal engineering projects throughout Ontario.

Kalju Ojala

W. J. Adams M.E.I.C.

W. J. Adams, M.E.I.C. (Man. '50), of Underwood McLellan and Associates, has been appointed Vice President and Area General Manager for Manitoba. He will have offices in Winnipeg.

(Continued on page 90)

PERSONALS

(Continued from page 88)

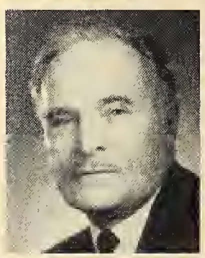

Franklin Dean


A. J. LeBlanc, M.E.I.C.

G. Franklin Dean, Supervising Engineer of Lighting Service for the Toronto Hydro Electric Systems, has been elected President of the Illuminating Engineering Society for 1962-63. This marks only the second occasion in the 57-year history of the I.E.S. that a Canadian has been chosen to lead the Society.

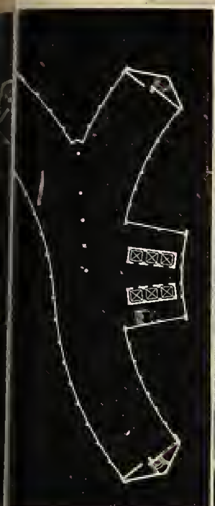
Lt. Col. A. J. LeBlanc, M.E.I.C. has been elected Chairman of the Board and Chief Executive Officer of Canadian Dredge and Dock Co. Limited. During World War II, Colonel LeBlanc served with the Royal Canadian Engineers. He is a member of the Order of the British Empire. He was formerly a Director and Project Manager for Atlas Construction Co. Ltd.; General Manager and Vice President, Operations at Toronto Iron Works and was Executive Vice President of Iroquois Constructors Limited of the St. Lawrence Seaway and Power Projects.

W. W. Timmins, M.E.I.C. (Toronto '23) has been appointed Resident Director for the Province of Quebec of S. A. Armstrong Limited, Mr. Timmins, President of W. W. Timmins & Company Limited has been associated with the Armstrong company for more than twenty years. In his new position, he will be concerned with the complete Armstrong line throughout Quebec. He will be located in Montreal.


J. E. Cranswick


W. W. Timmins M.E.I.C.

J. E. Cranswick has been appointed vice president, apparatus sales, Canadian Westinghouse Company Limited. Formerly vice president of the wholesale division, Mr. Cranswick will be responsible for national sales of the company's products as well as activities of the Wholesale Division.



Library Notes

Prepared by the Library, The Engineering Institute of Canada

Book notes marked by an asterisk have been provided through the courtesy of The Engineering Societies Library in New York.

BOOK REVIEW

LASTVERTEILUNG BEI PLATTENBALKENBRUCKEN.

A practical manual on load distribution in concrete slab bridges with cross-beams. The theoretical analysis is carried out in Part A; followed by numerical examples in Part B for cases with two, three, four, and five solid longitudinal supports and for two hollow beam supports. The latter half of the book contains the tabulated values that apply to the foregoing cases. (Heinrich Trost. Dusseldorf, Werner-Verlag, 1961. 246., DM 54.00.)

***GRUNDBAUPRAXIS.**

A well illustrated treatise on foundation engineering beginning with the fundamentals of soil mechanics. Major sections are devoted to footings, retaining walls, frameworks and trestles, deep foundations with various types of piles including sheet piling, deep foundations utilizing well points or caissons, compressed air work, and various special types of foundation construction. (Ernst Bachus. Berlin, Springer-Verlag, 1961. 468p., DM 66.00.)

ENGINEERING MANAGEMENT AND ADMINISTRATION.

Administrative methods for engineering departments are described in this handbook, which deals with the traditional responsibilities of the administrator and of the development and design engineering departments. Procedures for budget administration, personnel acquisition and training, distribution lists, engineering records, experimental shop and test operations, patents, design changes, and parts listing are outlined simply and clearly. (Val Cronstedt. Toronto, McGraw-Hill, 1961. 345p., $9.75.)

FOUNDATION DESIGN SIMPLY EXPLAINED.

The problems which arise in designing foundations are set down in relatively simple fashion, and the various ways in which these problems can be approached are presented. (John Faber and Frank Mead. Toronto, Oxford, 1961. 115 p., $2.25.)

SCHRIFTTIUM UBER BODENMECHANIK III.

This third volume adds another 5400 references to the 13200 contained in volumes I and II. The main divisions are: soils and soil exploration; soil properties; soil statics and dynamics; ground, interstitial, and surface water; foundation engineering, hydraulic structures, mining engineering, etc.; road and railway construction, earth works, agricultural engineering. The table of contents is in German, English, and French, and includes a detailed decimal classification of the field. (Comp. by Hans Petermann and Herbert Kühn. Bad Godesberg, Germany, Kirschbaum Verlag, 1961. 363p., no price given.).

ELECTRONICS: A BIBLIOGRAPHICAL GUIDE.

This comprehensive guide to bibliography sources in electronics literature is divided into 68 sections. The period covered is from 1945 to 1959, although a number of historical books, standard textbooks, and major bibliographies of earlier date are included. (C. K. Moore and K. J. Spencer. London, MacDonald, 1961. 411p., 65/-.)

PROGRESS IN NON-DESTRUCTIVE TESTING, VOLUME 3.

This third volume discusses optical methods in non-destructive testing, xeroradiography, x-ray spectrochemical analysis, dynamic mechanical properties and structure of polymers, hysteresis methods of non-destructive testing, coupled circuit theory for electromagnetic testing, and x-ray microscopy. (Ed. by E. G. Stanford and J. H. Fearon. Galt, Brett-Macmillan, 1961. 272p., $12.)

THE ENGINEERING INSTITUTE LIBRARY

The publications mentioned in these notes are now available in the Library and may be borrowed by members of the Institute. Two items may be borrowed at one time for a period of two weeks, excluding time in transit.

Library hours are: Monday to Friday: 9 a.m. to 5 p.m. All requests and enquiries should be addressed to the Librarian at 2050 Mansfield Street, Montreal.

ELECTROPLATING ENGINEERING HANDBOOK, 2ND ED.

The present edition incorporates changes in practices and equipment and expands the coverage with respect to plating and metal finishing. Numerous tables, charts, plans, and illustrations complement the text. (Ed. by A. K. Graham. New York, Reinhold, 1962. 774p., $18.50.)

GYROSCOPES: THEORY AND DESIGN.

The theory and practice of high-precision gyroscopics is presented in rigorous fashion. Prepared by eleven authorities, this work discusses the design of single- and two-degree of freedom gyros; error analysis and optimization of guidance parameters in inertial guidance systems; properties and design requirements of spin motors, pickoffs, torquers, and other electrical elements of gyros; and testing procedures for evaluating gyro performance and their interpretation. A feature is an extensive discussion of "Schuler tuning" and its relation to the earth's curvature. (Ed. by P. H. Savet. Toronto, McGraw-Hill, 1961. 402p., $14.75.)

PROGRESS IN INDUSTRIAL GAS CHROMATOGRAPHY, VOL. 1.

The initial volume in a new series intended to implement the available literature on gas chromatography. It consists of the Proceedings of the Advanced Sessions of the Third Annual Gas Cromatography Institute, held in April, 1961, at Canisus College, Buffalo, N.Y. (Ed. by H. A. Szymanski. New York, Plenum, 1961. 235p., $8.50.)

SWITCHING CIRCUITS FOR ENGINEERS.

The aim of this work is to present the subject matter in such a way as to be readily understood and applied by the logical design engineer. Much original material is included, such as methods of minimizing relay and electronic trees and a method of detecting and identifying symmetric functions. Almost half of the text is devoted to sequential circuits, and in the examination of the synthesis of pulse-input sequential circuits, an original method for obtaining flip-flop excitation expressions is given. (M. P. Marcus. Englewood Cliffs, Prentice-Hall, 1962. 296p., $12.)

(Continued on page 102)

THE IMPORTANCE OF MEMBERSHIP IN THE E.I.C.

At its meeting of February 3rd, 1962, the Council of the Institute adopted a policy which, inter alia:

"Continually serves to enhance the role of the Institute as the collective entity of the profession in the field of national, voluntary, professional and learned society."

"Recognizes that other voluntary professional and learned societies have a definite role to play, based on historical development, and supports them in those endeavours which are of mutual interest."

I'd like to say why I think you cannot afford to overlook the very substantial values attached to membership in E.I.C. If you are a member already, these observations will be helpful in talking to potential members because *you are a member of the Committee on Membership team.*

What are these very substantial values attached to membership in E.I.C.?

If you are a younger member, just entering on your professional career, don't fall into the pitfall of thinking your "sheepskin" makes you an engineer. It doesn't. However, it did give you the basic training needed by an engineer, it did develop orderly processes of thought. Only exchange of technical ideas and experience with other engineers can provide that wealth and knowledge and ability to apply it which makes an engineer. The only place this can be obtained is the learned Society of your choice.

We hope your choice is the Engineering Institute of Canada.

There's an aspect of membership you should not overlook. It provides an opportunity to participate in discussion, in a more formal manner, at Branch and other meetings; to present a paper on an engineering subject; to develop your ability to participate in group activities in your profession. It may well turn out you will be invited to take part in committee activities. This will give you an opportunity for still further development.

As you grow older, you'll find that participation in the technical activities of E.I.C. is an easy corrective for that obsolescence which is becoming of increasing significance —the obsolescence of a formal technical education due to the growing rate at which technology is becoming the very warp and woof of the fabric of our nation.

It has been said that the half-life of a technical education is 15 years. I think it is not over 10 years at the most. Think of the significance of this for yourself. You can overcome this obsolescence through full use of the facilities at the "Lifetime University"—your E.I.C.

As you grow older you have an obligation to add to that fund of engineering knowledge which your professional forebears bequeathed to you. You can repay your withdrawal from the common fund by contributing from your professional know-how through the medium of papers, committee work and active participation in Branch and Institute activities.

Do you know that, if you find yourself seeking employment, the Institute operates an Employment Service which has helped arrange employment opportunities for many members over the years.

Do you know that the Institute has co-operative agreements with many of the United Kingdom Institutions, Commonwealth Engineering Societies and with the U.S.A. Founder Societies whereby many of the advantages of membership therein can be obtained at members' rates? I refer specifically to their publications.

Do you know that the Institute has an excellent Library, at your service? Use it. Write in to the Librarian when you need help. You'll receive prompt and amazingly helpful service. It is free.

Let me add one thought. You'll find that the more you participate in its work the more Institute helps you be a better engineer, able to contribute more fully in the work of our profession.

Remember you owe it to your fellow engineers to assist them find their role in the engineering world. How? Encourage them to join the Institute. Invite potential members to see the Institute in aetion.

Finally, don't forget that Institute officers and Headquarters staff are always glad to talk over Institute matters with members.

F. L. Lawton, President.

L'IMPORTANCE DE L'AFFILIATION A L'I.C.I.

A sa réunion du 3 février 1962, le Conseil de l'Institut a adopté comme ligne de conduite, entre autres, de:

"Tendre continuellement à mettre en valeur le rôle de l'Institut comme personne morale représentant, en tant que société nationale, de caractère professionnel et intellectuel,, les ingénieurs, qui restent libres d'y adhérer."

"Reconnaître le rôle indiscutable qui appartient à d'autres sociétés de caractère professionnel et intellectuel, volontairement formées en partant de facteurs historiques, et les soutenir dans tous leurs efforts orientés vers l'intérêt commun."

Permettez-moi d'expliquer pourquoi j'estime que vous ne pouvez négliger les avantages considérables qui accompagnent l'affiliation à l'Institut canadien des Ingénieurs. Si vous en êtes déjà membre, ces remarques vous aideront à convaincre d'autres membres en perspective, puisque *vous faites partie de l'équipe du Comité de recrutement.*

Quels sont les avantages considérables de eette affiliation à l'I.C.I.?

Si vous êtes un jeune membre, débutant dans la carrière, ne commettez pas l'erreur de croire que votre diplôme suffit à faire de vous un ingénieur. Vos études vous ont donné la formation essentielle, indispensable à l'ingénieur; elles vous ont appris à penser d'une manière raisonnée. Mais, seuls l'échange d'idées techniques avee d'autres ingénieurs et l'expérience qu'ils peuvent vous eommuniquer vous apporteront les connaissances théoriques et pratiques qui feront de vous des ingénieurs dignes de ee nom. Le seul endroit où vous puissiez les acquérir est dans la société professionnelle que vous aurez choisie. Nous formons le voeu que cette société soit l'Institut eanadien des Ingénieurs!

Il y a un aspect de cette affiliation que vous ne pouvez négliger: ce sont les occasions qui en découleront pour vous de participer à des discussions à titre quasi-officiel, lors de réunions régionales ou autres; de présenter une dissertation sur un sujet technique, d'apprendre à collaborer aux activités d'un groupe de professionnels partageant les mêmes intérêts que vous. Il pourra même arriver qu'on vous invite à faire partie d'un comité où vous trouverez maintes occasions d'enrichir vos connaissances et d'élargir votre expérience.

Avec le temps, vous constaterez que le fait de participer aux activités professionnelles de l'I.C.I. est un excellent correctif des idées désuètes qui accompagnent la décrépitude d'une éducation théorique, décrépitude qui survient de nos jours à une allure accélérée à mesure que la technologie prend une place plus grande dans le développement de notre pays.

On a dit que la durée utile d'une éducation technique est de quinze ans. Pour ma part, j'estime qu'elle ne dépasse pas 10 ans. Pensez à l'importance de ce fait! Vous pouvez éviter ce vieillissement rapide de votre formation en exploitant à fond, à votre profit, toutes les ressources de cette "université permanente" qu'est l'I.C.I.

En avançant en âge, vous avez le devoir d'apporter votre part de connaissances au trésor d'expérience technique que vos prédécesseurs vous ont transmis. Vous pourrez rembourser les emprunts faits à ce fonds commun sous forme d'articles dans les publications professionnelles, ou en faisant partie de comités d'études, ou en participant activement aux initiatives de votre Institut sur le plan régional ou national.

Saviez-vous que, pour ceux qui se cherchent un emploi, l'Institut dispose d'un service de placement qui a pu offrir à de nombreux membres, depuis sa création, des situations qu'ils n'auraient peut-être pas trouvées sans lui?

Saviez-vous que l'Institut possède des ententes avec plusieurs institutions du Royaume-Uni, sociétés d'ingénieurs du Commonwealth et sociéttés fondatrices des E.-U, conférant à nos membres de nombreux avantages, au même tarif que celui qui paient leurs propres membres? Cela est vrai, notamment, de leurs publications.

Saviez-vous que l'Institut dispose d'une bibliothèque très complète où vous pouvez puiser? Vous n'avez qu'à écrire au bibliothécaire. Vous trouverez particulierement rapide et précieux ce service gratuit!

Je me permets d'ajouter cette observation: plus vous participerez étroitement aux travaux de l'Institut, plus celui-ci vous aidera à vous perfectionner dans votre profession et plus vous pourrez, à votre tour, favoriser son développement.

Rappelez-vous que vous vous devez d'aider vos confrères ingénieurs à occuper la place qui leur revient dans le domaine de la technique. Le meilleur moyen, c'est de les encourager à s'affilier à l'Institut. Invitez les membres en perspective à venir voir à l'oeuvre l'Institut.

Enfin, soyez, assuré que les directeurs et le personnel de l'Institut se feront toujours un plaisir de discuter avec vous tous les sujets qui nous intéressent mutuellement.

F. L. Lawton, President.

Engineering Education in Canada

The first part of a two-part series on ENGINEERING EDUCATION IN CANADA was published in the September issue of The Engineering Journal.

Plans now call for the publication of part two in the JANUARY issue. Space limitations made it necessary to divide this collection of histories into a series.

Many significant institutions from all parts of Canada will be featured in the January Journal. It is not necessary to point out that the story of Engineering Education in Canada would not be complete without them.

On completion of the series, it is planned to make available a reprint, without advertising, of the complete story.


Throw out
machining,
grinding
and
inking?

SITUATIONS VACANT

MECHANICAL

MECHANICAL ENGINEER, A.M.E.I.C., B.Eng., McGill 1960, Diploma Business Administration (U.W.O.) 1961. One year's experience in Plant Engineering work. Experience in supervision of construction and installations of a new plant, cost reduction and cost analysis; also some draughting and design experience. Desires interesting engineering position, such as plant engineering or plant maintenance. Location preferred — Montreal or Quebec. File No. 267-M.

INDUSTRIAL ENGINEER — Young professional engineer, university graduate, minimum two years' experience. Preferably but not necessarily familiar with textile or carpet-making machinery. Responsible to Works Manager, and will be required to develop and improve manufacturing methods and equipment in a carpet plant located in Ontario. Full social welfare benefits. File No. 277-V.

MISCELLANEOUS

ELECTRICAL/MECHANICAL ENGINEER. Rapidly expanding Canadian firm has a requirement for an Electrical or Mechanical Engineer preferably with design experience on electric panels and diesel and gasoline generating sets to lead to the position of Chief Engineer. Please send complete resume of qualifications to File No. 280-V.

AN ADMINISTRATIVE OFFICER to organize administrative services for a research staff of 180. Several years' experience supervisory or administrative work desired. Salary $6,000 to $7,500. Apply to The Director, Research Council of Alberta, Edmonton, Alberta.

ENGINEERS FOR MANAGEMENT—project, design, sales, research, development and control. Graduates of most types and ages required by clients of the Technical Service Council, a non-profit, industry-sponsored placement service. Write 2 Homewood Ave., Toronto 5, Ontario or 1500 Stanley Street, Montreal 25, Que. for an application. There is no charge for work done on your behalf. File No. 6648-V.

MINING

FOREIGN EMPLOYMENT. MINE GENERAL SHIFT FOREMAN—B.S. degree in Mining Engineering. Fluent knowledge of English and Spanish. Chilean subsidiary of large North American mining company desires to contract a Mine General Shift Foreman for a permanent position in Chile. Applicants should have 3 years' underground mining experience (metal mining preferred) with at least one year in a supervisory capacity. Primary function would be to translate into execution all planning and co-ordinate all operations required for the mining of 34,000 tons daily. Excellent opportunity—large copper company, central Chilean area. Employment on contract basis in multiples of two years. Home leave vacation of two months at the end of two year contract. Transportation both ways and salary while travelling paid by Company. Provision also made to transport household effects. In reply, give complete details and references to File No. 278-V.

TEACHING

TWO ACADEMIC POSITIONS available on January 1 and/or July 1, 1963, at the assistant or associate professor's level in (1) Structural and Engineering Mechanics, and (2) Traffic Studies and Transportation Engineering. The applicants should hold either a doctoral degree or a Master's degree with several years of practical experience in the field. Duties will include instruction at the undergraduate level and the development of a graduate study and research programme. Current salary scales for the academic year are $7,000 to $9,000 for an assistant professor, and $9,000 to $11,000 for an associate professor. Summer research stipends are available. Apply to the Chairman, Department of Civil Engineering and Engineering Mechanics, McMaster University, Hamilton, Ontario.

• Library Notes

(Continued from page 94)

POWDER METALLURGY.

The proceedings of an International Conference held in New York in 1960, sponsored by the Metal Power Industries Federation and the Powder Metallurgy Committee of the AIMMPE. The 42 papers presented were written by experts from all over the world, and are divided into four sections. The first of these is concerned with the mechanism of sintering, and the papers cover not only general theory, but also the sintering of specific materials. The six papers in the second section deal with dispersion strengthening. The third group of papers discuss powder metallurgy technology, and newer methods for forming metal powder into useful shapes. The fourth part deals with materials, and applications such as refractory metals, cemented carbides, self-lubricating bearings, structural parts, friction materials, and the light metals. (Ed. by Werner Leszynski. New York, Wiley/Interscience, 1961. 847p., $25.00.)

FINANCIAL POST SURVEY OF OILS, 1962.

Following the usual practice, the larger part of the Survey is devoted to reviews of Canadian oil and gas companies, giving for each address, company history, properties, wells, balance sheet, etc. Information is also given on dead and dormant companies, and on Canadian production statistics, gas reserves, price range of stocks, and refinery capacity, and the Survey also includes maps of oil and gas areas. (Toronto, Maclean-Hunter, 1962. 216p., $5.00.)

*FESTIGKEITSBERECHNUNG VON BAUELEMENTEN DES DAMPFKESSEL-, BEHALTER- UND ROHRLEITUNGSBAUES.

A study on stress calculations for the structural parts of boilers, vessels and pipelines, analyzing the actual formulas for computation as well as offering proposals for further development. The topics discussed include cylindrical walls under internal and external over-pressure; arched and conical bottoms; flat bottoms, flanged joints, etc. (Siegfried Schwaigerer. Berlin, Springer, 1961. 127p., DM 32.50.)

THEORIE DES ASSERVISSEMENTS PAR PLUS-OU-MOINS.

Translated from the Russian, this text on servomechanisms commences with two introductory chapters giving definitions and base equations. These are followed by chapters on transitory regimes and the stability of the state of equilibrium. In the main part of the book, the author considers self- and forced oscillations, the conditions for their existence, the determination of the fundamental parameters of the oscillations, the calculation of the oscillations themselves, and stability. Two final chapters cover problems of linearization and optimization of these systems. (J. Z. Cypkin. Paris, Dunod, 1962. 369p., 78NF.)

THEORIE ELECTRONIQUE DE LA CATALYSE SUR LES SEMI-CONDUCTEURS.

This text covers the electronic theory of catalysis; different types of adsorption, chemisorption; the catalytic activity of semi-eonductors; surface and internal inter-action in a semiconductor; correlation between catalytic activity and electric conductibility, etc. (T. Wolkenstein. Paris, Masson, 1961. 150p., 30NF.)

INSTRUMENT BALL BEARINGS.

The fourth in a series of surveys on instrument parts, this volume deals with small precision ball bearings used in instruments and other light apparatus. The series attempts to list all available published material, in all languages, and includes 144 references. (P. J. Geary, Chislehurst, Kent British Scientific Instrument Research Assoc., 1961. 73p., 23/6.)

ELECTROMECHANICS.

This introduction to electromechanical energy conversion stresses the principles fundamental to all electromechanical devices. The author applies these principles not only to generators and motors, but also to transducers and rotating amplifiers, to sensing devices and indicating instruments, and to microphones and speakers. (H. H. Skilling. New York, Wiley, 1962. 475p., $10.)

(Continued on page 126)

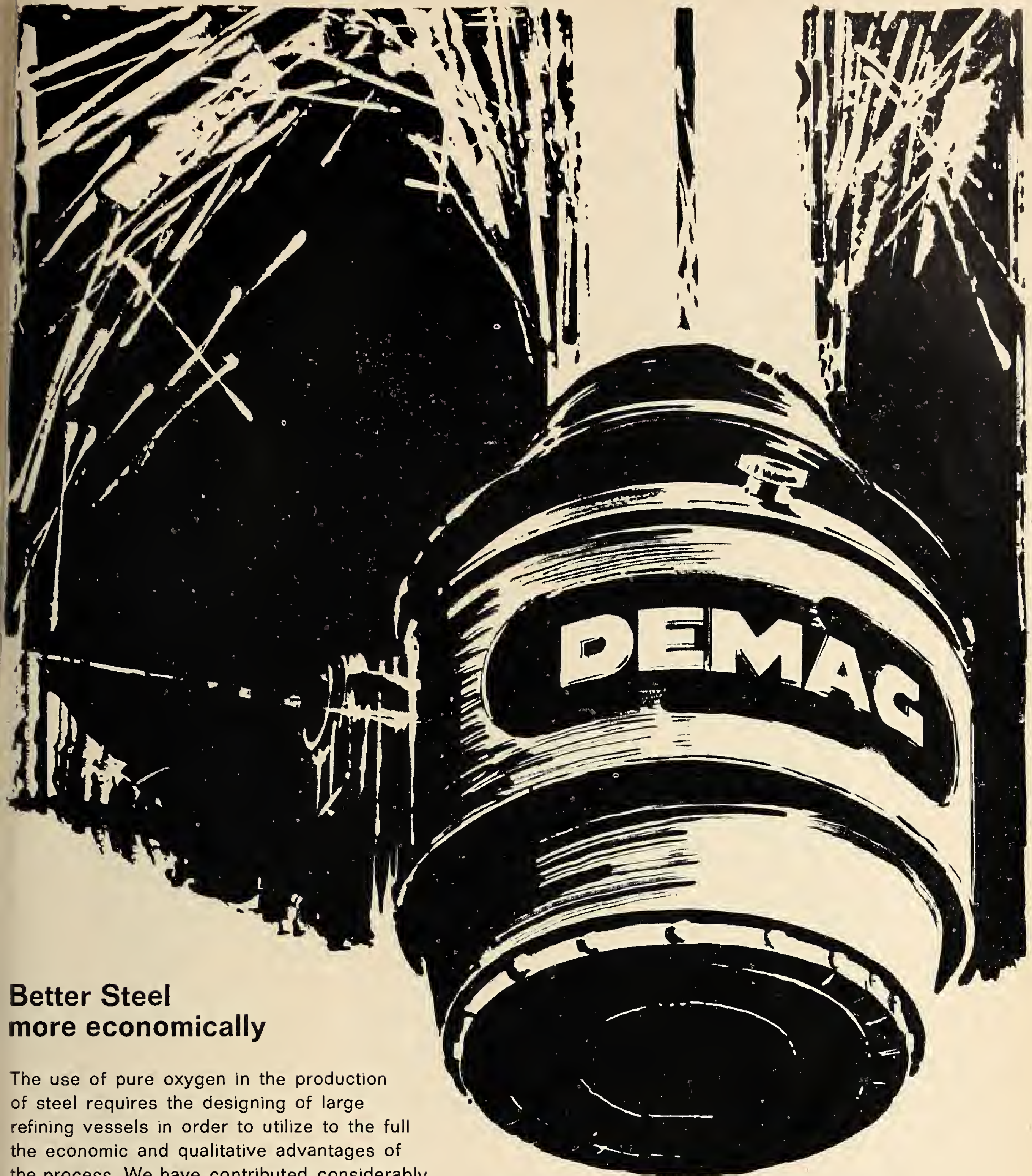
NOTICE TO ADVERTISERS

DEADLINE — Please note that requests for insertions must be submitted in writing not later than the **15th of the preceding month.** Cancellations: same as above.

SITUATIONS VACANT — Classified rate: $6 per column-half-inch per insertion. Display rates: Per insertion — 1/12 page — $100; 1/8 page — $120; 1/6 page — $195; 1/4 page — $215; 1/3 page — $285; 1/2 page — $345.

DATE IN CIRCULATION — 20th of month.

SITUATIONS WANTED — Accepted free of charge from Members of The Engineering Institute of Canada only.



Better Steel more economically

The use of pure oxygen in the production of steel requires the designing of large refining vessels in order to utilize to the full the economic and qualitative advantages of the process. We have contributed considerably to the development of the LD and LDAC processes by the construction of modern crucibles and lance installations.
The largest LD plant in Europe with two 175-ton LD crucibles has just been completed.
Further information may be obtained from

DEMAG Industrial Equipment Ltd.,
2400, Highway 122, P. O. Box 1240 Clarkson

DEMAG AKTIENGESELLSCHAFT DUISBURG GERMANY

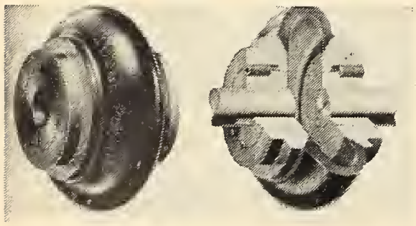
Industrial Briefs

ML-8130 Machlett Tubes

THE TWO MACHLETT Direct view storage tubes introduced by Raytheon Canada Ltd., feature very high writing speeds. At full brightness and with uniform storage characteristics, the ML-8130 offers a read-out capability exceeding 500,000 inches per second. The ML-8139 writes at a rate of more than 150,000 inches per second. Both tubes are focused electrostatically and offer resolution characteristics up to 80 lines per inch at full brightness. Deflection is accomplished electrostatically in the ML-8130 and magnetically in the ML-8139. The fast-writing tubes offer direct read-outs for airborne systems such as radar, search navigation and ground clearance systems. Aboard ship, the tubes are applicable to long-memory displays for sonar and true motion radar systems.

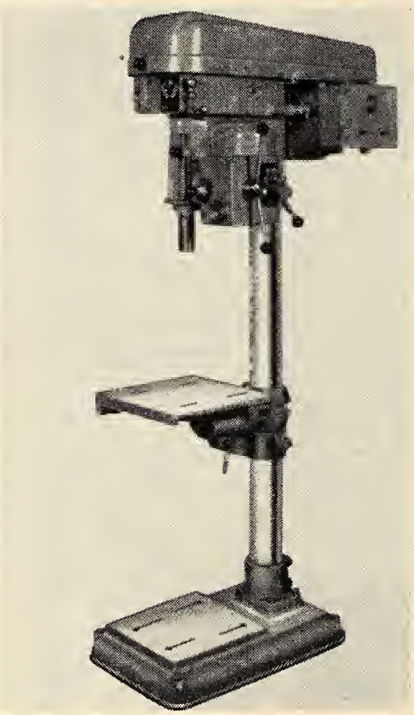
POLY-FLEX, a new flexible cushioning coupling for small shafts, has been announced by United Steel Corporation Limited-Dodge Manufacturing Division. This product, an adaption of Dodge Para-flex, compensates for parallel shaft misalignment up to four degrees, cushions shock loads, absorbs vibration and takes end float up to 5/16 inch. The PB40 is approximately four inches in diameter, is constructed of polyurethane permanently bonded to two close-grain gray iron flanges. Mounting is simple, and bushings are easily changed for use on shafts of different sizes.

Poly-Flex Flexible Cushion Coupling

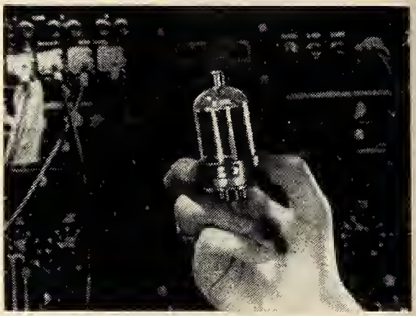


THE "CANADIAN BUFFALO", No. 20 drilling machine introduced by Canadian Forge & Blower Co. Ltd., Kitchener, has a capacity of one inch in mild steel, features easily located controls, streamlined belt guard and five step pulleys geometrically progressed to permit belt-changing from step to step without adjusting the motor bracket. The spindle return spring can be adjusted by hand. The machine is available in floor models, standard bench drill with tilting table, and production table models.

"Canadian Buffalo" No. 20



AN OUTLINE OF PRESTRESSED concrete applications in a variety of structures is covered in a new book produced by the Steel Company of Canada, Limited. Included in the book is essential data on the use of high tensile steel wire and strand in prestressing techniques. An important section of the book is devoted to the procedure for calculating yield point, and the modulus of elasticity from the stress-strain diagrams provided with each shipment of Stelco high tensile steel wire and strand. This book is obtainable free from the Steel Company of Canada, Limited, Wilcox Street, Hamilton.



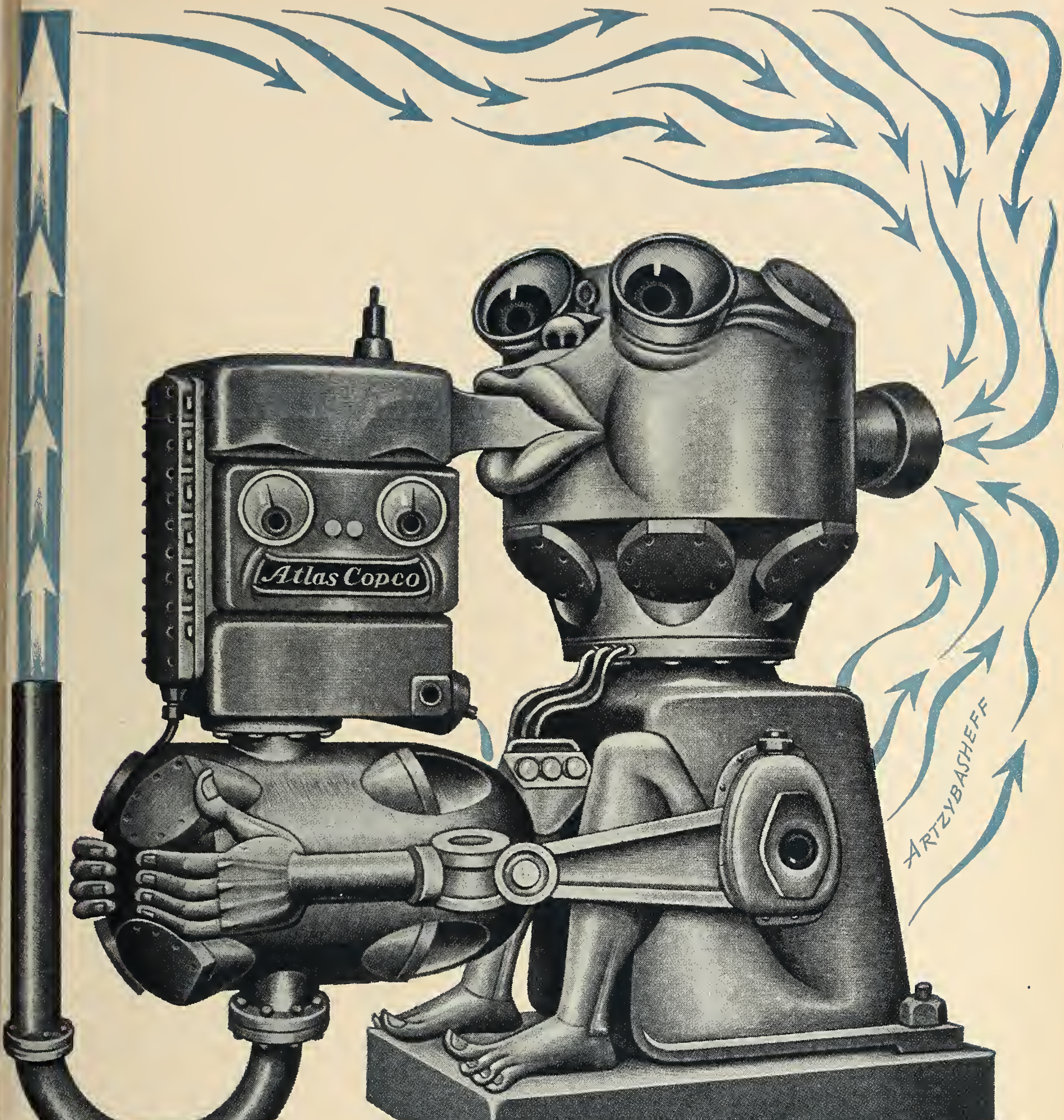
Beam Power Pentode

THE INDUSTRIAL COMPONENTS Division of Raytheon Canada Limited has announced a beam power pentode, designed for RF or AF power amplifiers, oscillators, frequency multipliers, or AF modulators in mobile or fixed equipment. The CK6146, capable of 25 watts dissipation, and operable up to 175 mc at reduced ratings, features stability at reduced heater voltage.

T-BOLT CLOSURES for low-pressure applications have been introduced by Tube Turns of Canada Limited, Toronto. The factory-assembled units have semi-ellipsoidal heads hinged to welded hubs, self-energizing static "O" rings and a suitable number of swinging T-bolts, varying with nominal pipe size, to maintain a tight seal. These closures are designed to meet the requirements of filter manufacturers, tank and vessel fabricators and chemical processing plants for manways and covers on storage tanks, mixing vessels, separators and filters. The closures, available from 8 inches to 42 inches in carbon steel, are rated for 75 p.s.i. service at 250 degrees Fahrenheit.

(Continued on page 106)

T-Bolt Closures



The ER8, humanized in Boris Artzybasheff's unique style, is the newest in a long series of heavy-duty, two-stage, water-cooled industrial air compressors. It delivers 2290 cfm at 100 psi at its maximum rating of 514 rpm. At 450 rpm, its 2020 cfm for 363 shaft hp gives 18 hp per 100 cfm. This is probably a higher efficiency than that of any equivalent machine available in Canada today.

Since 1952, about 300 Canadian companies have installed more than 500 Atlas Copco stationary compressors from 1 to 600 hp. This points up the double fact that they are good machines and that Atlas Copco is a good firm to deal with.

FOR PROFIT'S SAKE, GET A QUOTE FROM COPCO

Atlas Copco Canada Ltd. 745 Montreal-Toronto Blvd., Dorval, P.Q.
Branches & representatives coast to coast.

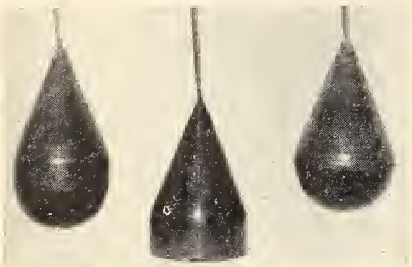
Atlas Copco puts compressed air to work for the world

INDUSTRIAL BRIEFS

(Continued from page 104)

CANADIAN GENERAL ELECTRIC has announced a new line of ringless meter sockets, flexible in design to accommodate individual electric utility requirements, and available for 100-ampere single-phase service. The socket line is welded throughout to provide weatherproof protection for the meter. It is constructed of 16-gauge zinc coated steel. The sockets are available in three sizes for 100 amp ratings, eight inches wide, with lengths of 8.8, 10 and 12 inches.

Liquid Level Regulators



THREE NEW MODELS of a simple type of liquid level regulator has been introduced into Canada by Flygt Canada Limited. The regulators are for use in diverse liquids with specific gravities between 0.75 and 1.2. The regulator consists of a mercury in a plastic casing, suspended on a three conductor flexible cable in lengths of 20, 40 and 60 feet. When fluid level changes, the regulator tilts and the switch closes the circuit to start or stop a pump or actuate an alarm.

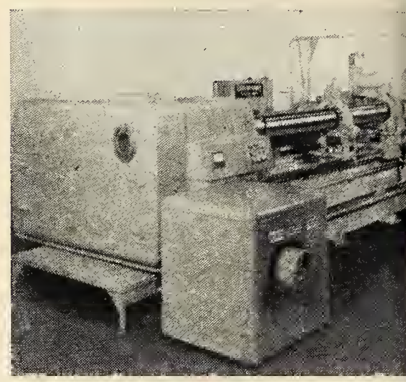
Model PNSC Strapping Tool.

AN ALL-POWER-OPERATED, push-type strapping tool has been introduced by Signode Steel Strapping Co. The Model PNSC will not tension unless the tensioning and sealing mechanisms are properly aligned and will not sever strapping from coil unless the seal has been properly notched. It utilizes air power to tension, seal, and cut the strapping and is intended for use on narrow, irregular or curved surfaces.

A SELF-CONTAINED transfer function computer, available from Glendon Instrument Co. Ltd., Scarborough, Ont., is so simple to use, claim the manufacturers, that an unskilled operator can obtain accurate and consistent results in a matter of minutes. This eliminates the series of measurements often associated with determining transfer functions, and the graphical analysis by specialist mathematicians. The SA100 measures transfer functions having terms in the numerator and denominator up to the fourth order and sixth order respectively. The computer can be used on linear as well as non-linear systems, and delivers values directly. The SA100 can be a valuable production test instrument.

A MACHINE DESIGN CONCEPT which enables a single machine tool to perform both hobbing and thread milling operations has been introduced by the A. R. Williams Machine Company Ltd., Toronto. The Model HH Mark III-C machine accommodates work up to 30 inches in diameter, and 144 inches long. It will hob straight or helical splines or gears up to 16 inch diameter with conventional gear and spline hobs. The machine will mill single or multiple-start threads up to 16 inches in diameter with conventional milling cutters.

Model HH Mark III-C



CANADIAN WESTINGHOUSE COMPANY LIMITED has introduced a new load interrupter switch (Type LBF) with high fault closing capabilities. This fuse does not depend on fuses in series for protection and can be closed against fault currents of up to 61,000 amperes without sustaining damage. A spring-loaded, quick-break blade ensures fast load interruptions without requiring maintenance. The unit is available as a co-ordinated three-pole assembly which includes the operating mechanism. It is completely factory-adjusted and requires only four mounting bolts for field installation. Design features include built-in interlocks and angle type terminals which permit bus connections in two planes.

A NEW LINE of oil lubricated process pumps, designed to cut hours from servicing time, has been developed by Canadian Allis-Chalmers Limited. The line includes 26 centrifugal pump sizes requiring only three bearing frame assemblies. The pump is capable of handling corrosive or hot liquids, and has many applications in the chemical, pulp and paper, and mining industries.

Developments

Information contained in this section has been obtained from press releases. Mention of products and services does not imply endorsement by the Institute.

Discussion

(Continued from page 74)

tional instruction films in many fields of engineering. There has also been a lack of films to aid in teaching kinematics, and Professor Pearce is to be commended for his efforts to fill this void.

In teaching the subjects of kinematics and theory of machines, all too often the student has a limited prior knowledge of mechanisms. As the author indicates, the use of models will amply serve to impress upon him the motions of the various links making up the mechanism. Next, the student is faced with analyzing the mechanism, and as the lecturer unfolds and explains the theory, the student absorbs the analysis of velocities and accelerations with little difficulty. However, at this point the student acquires the impression that the analysis as presented is either representative for all positions of the cycle, or the lecturer has mysteriously chosen and presented that position where both the velocities and accelerations are simultaneously a maximum. The conception that velocities and accelerations of each link vary throughout the cycle seems difficult to grasp, and in addition the manner in which they vary is unquestonably difficult to conceive. Successful instruction of this phase of kinematics requires time consuming effort on the part of both the lecturer and student.

The writer has had the opportunity of using the film whose production is described in this paper. A considerable portion of the course on kinematics and theory of machines at the University of Toronto had been completed and the idea of phase dependency of velocity and accelerations was being stressed when the film became available. The presentation of the 10-minute film had a most gratifying impact on the class and left a clear impression of phase dependency. Although only the four-bar mechanism was used, the class appeared more aware of phase dependency of other mechanisms throughout the remainder of the course.

Because of the nature of kinematics the method used in producing an animated film must be essentially that employed in the production of cartoon films. This suggests that there are few possible short cuts in the method used by the author, making the production of such films unavoidably time consuming.

In conclusion the author should be encouraged to continue his work on teaching aids for kinematics, and it is to be hoped that he will produce more such animated films. Such films will surely prove to be invaluable for more successful engineering instruction.

Discussion by

J. Deane

I have been most impressed by the author's method of presenting a concept that is normally rather baffling to new students. I wonder if the author has given any thought to the use of an automatic plotter to transform the output of the digital computer to a diagram on paper. Nowadays, such plotters are "off-the-shelf" items. It would appear that elimination of this bottleneck would shorten the whole film production system considerably.

Discussion by

I. W. Smith

Professor Pearce is to be congratulated on having made a considerable contribution to the teaching of mechanism kinematics, by first preparing an education film and secondly by making available the details of its production. By the use of relatively simple equipment and a straightforward procedure he has produced a very credible result. He also modestly omits mention of the large amount of skill, patience, and time that he contributed to make it a success.

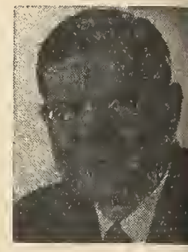
The teaching of mechanism kinematics has always been defected by a lack of adequate visualization by the student. He is usually in the sophomore year when the course is taken and has had very little actual contact with mechanisms that employ cranks, linkages, or cams. Working models that he can personally operate are helpful but, as the author points out, only a limited return can be expected from their use. I am sure every educator faced with this problem has considered the use of an animated film.

The usual engineering approach to a problem includes an attempt to balance the cost of the project against the benefits to be derived. In education the cost factor is a balance between capital outlay, teacher time and student time. The benefits derived, in the form of effective teaching, are difficult to assess as the author has pointed out. All good teachers have a desire to perfect their teaching methods, but achieving absolute perfection usually requires far more preparation time than is normally available. So a compromise must be made, resulting in

(Continued on page 118)

PERSONALS

(Continued from page 90)

G. H. Blumenauer M.E.I.C. E. E. Moore

George H. Blumenauer, M.E.I.C. (U.B.C. '45) has been elected President of Otis Elevator Company Limited. Mr. Blumenauer joined the company in 1946. After varied experience in the Sales and Service Divisions, he was appointed Assistant District Manager, and then District Manager in the Toronto area. In 1961, he was elected vice-president.

E. E. Moore has been appointed district manager, industrial engines sales at the newly opened Calgary, Alberta branch office of the Orenda Engines Division of Hawker Siddeley Canada Ltd. Mr. Moore, an engineering graduate of Oklahoma State University, will have his office in Calgary's Wales Hotel Building.

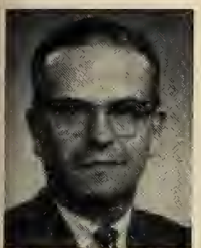
John L. Durrell, M.E.I.C. (Queen's '51) has been appointed Division Engineer, Mining and Metallurgy, Foundation of Canada Engineering Corporation Limited. Mr. Durrell joined FENCO in 1955 as a Group Leader, Mechanical Services. Two years later he became Project Engineer co-ordinating FENCO work in mining and metallurgy and heavy industry. He will be based in Toronto.


J. L. Durrell, M.E.I.C. D. A. Cockburn

Allan S. Binns has been appointed senior salesman, Toronto Branch, for the Industrial Products Group of Honeywell Controls Limited. Mr. Binns will be responsible for pulp and paper, and scientific accounts in the Toronto area. **Donald A. Cockburn** has been appointed Market Supervisor-Mining for Honeywell. Mr. Cockburn will be responsible for market sales and application of instrumentation in the mining and metal processing industries.

H. P. Klassen, M.E.I.C. (Sask. '52), of Underwood McLellan and Associates Limited, has been named Vice President and Area General Manager for Saskatchewan. His offices will be located in Saskatoon and Regina.

Donald C. Turner, M.E.I.C. (McGill '32) has been named assistant secretary of the Canada Starch Company Limited. Mr. Turner is past-chairman of the Brockville Branch of the Institute, and is a fellow of the Chemical Institute of Canada. In addition to his new duties, he will continue in his present capacity as chief personnel officer.



D. C. Turner, M.E.I.C.

H. P. Klassen, M.E.I.C.

L. H. Fransen, M.E.I.C. (U.B.C. '52) has been appointed Assistant to the Superintendent of Engineering Services, Engineering Division of The Consolidated Mining and Smelting Company at Trail, B.C.

D. J. Inglis, A.M.E.I.C. (U. of Aberdeen '50) has been named Manager of the newly formed Pollution Control Division at Flygt Canada Limited. Mr. Inglis has had extensive experience in the sanitary engineering field, including responsibility for the complete design, installation and operation of various units in Flygt's new line of sewage equipment.

D. J. Inglis, A.M.E.I.C.

J. K. Young, M.E.I.C.

J. K. Young, M.E.I.C. (U.N.B. '45) has established a new construction company specializing in drainage construction and soft earth tunneling. The firm, Kilbarco Construction Ltd., will have offices in Montreal, Fredericton, N.B. and Amherst, N.S. Mr. Young was formerly associated with Armco Drainage & Metal Products Canada Ltd.

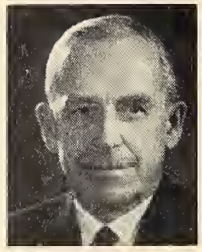
(Continued on page 112)

(Continued from page 111)

Gordon W. Walker
M.E.I.C.

Gordon W. Walker, M.E.I.C. (Alta. '49) has been appointed Manager of Technical Services at The Alberta Gas Trunk Line Company Limited. Mr. Walker has had a broad background in pipeline design and construction. In his new position, Mr. Walker will be responsible for the design and construction of gas pipeline projects.

Obituaries



E. W. R. Steacie
M.E.I.C.

E. W. R. Steacie, HON. M.E.I.C. President of the National Research Council and one of the world's foremost physical chemists, died at Ottawa August 28. He was 61.

Dr. Steacie was internationally renowned as a scientist and at the time of his death was serving a three-year term as President of the International Council of Scientific Unions, the chief non-governmental organization of co-ordinating international activity in science.

During the 1962 Annual Meeting of the Engineering Institute of Canada Dr. Steacie was awarded an Honorary Membership for his outstanding service to the profession.

Dr. Steacie was born in Montreal and earned his B.Sc., M.Sc., and Ph.D. degrees from McGill, where he subsequently taught until 1939. In that year he joined the National Research Council as Director of the Division of Chemistry. He became Vice-President (Scientific) in 1950 and in April, 1952, was named President of the NRC.

E. G. M. Cape, DSO, M.E.I.C., supervisor of the construction of many well-known buildings in Eastern Canada, died September 16 in Montreal. He was 84.

Col. Cape was born in Hamilton, and was educated at McGill University where he graduated with a BSc. degree in 1898. He became a Member of the Institute in 1899. He became a Life Member in 1947. Before founding E.G.M. Cape Co. in 1906, he was assistant engineer of the Lake Superior Power Co., and then chief engineer of the Canada Car Co. in Montreal. At the outbreak of World War I, he recruited and commanded the 3rd Canadian Seige Battery, later known as "Cape's Battery". Col. Cape was awarded the DSO for bravery under fire during the battles of the Somme and Vimy Ridge during World War I.

Col. Cape served as president of his firm until 1950 when he became chairman of the board. He became honorary chairman in 1958.

Engineers' Ball

The Hamilton Branch of the E.I.C. is holding its annual Professional Engineers' Ball at Fischer's Hotel in Hamilton on Saturday, November 10.

A limited number of tickets are available to this dinner dance which will honour the 75th Anniversary of the Institute.

FURTHER INFORMATION MAY BE OBTAINED FROM B. N. PETERSON, ROBERTSON-IRWIN LIMITED, HAMILTON

77TH ANNUAL MEETING

of the Engineering Institute of Canada

CHATEAU FRONTENAC QUEBEC CITY

May 22 - 24, 1963

Plan NOW To Attend

COMING EVENTS

Sixth World Power Conference. Melbourne, Australia. October 20-27.

Chemical Institute of Canada. Engineering Institute of Canada. Chemical Engineering Division. 1962 Canadian Chemical Engineering Conference. Sarnia, Ont. October 22-24.

Institute of Radio Engineers. Electronic Devices Meeting. Washington, D.C. October 25-27.

American Institute of Mining, Metallurgical and Petroleum Engineers Inc., Metallurgical Society. Fall Meeting New York. October 29-November 1.

Society for Non-Destructive Testing. 22nd Annual Meeting. New York. October 29-Novembr 2.

Society of Automative Engineers Inc. Combined National Fuels and Lubricants; Powerplant and Transportation Meetings. Philadelphia, Pa. October 29-November 2.

Institute of Radio Engineers, American Institute of Electrical Engineers, American Institute of Mining, Metallurgical and Petroleum Engineers Inc., American Institute of Physics. Eighth Conference on Magnetism and Magnetic Materials. Pittsburg, Pa.. Nov. 12-15.

American Petroleum Institute. 42nd Annual Meeting. Chicago. November 12-15.

Meetings of Special Interest to E.I.C. Members

OCTOBER 22-24
Joint CIC-EIC Chemical Engineering Divisional Technical Conference at Sarnia

FALL OF 1962
Newfoundland Regional Conference

EARLY DECEMBER 1962
Northwestern Ontario Regional Technical Conference at Fort William

FALL OF 1963
St. Maurice Valley Regional Technical Conference at Grand'Mere

CALL FOR PAPERS FOR THE FOURTH JOINT AUTOMATIC CONTROL CONFERENCE

THE FOURTH JOINT AUTOMATIC CONTROL CONFERENCE WILL BE HELD AT THE UNIVERSITY OF MINNESOTA IN MINNEAPOLIS ON JUNE 19-21, 1963. PAPERS ON CONTROL THEORY, APPLICATIONS, AND COMPONENTS NOW ARE BEING INVITED.

The sponsoring societies of the JAAC are the American Institute of Chemical Engineers (which has prime responsibility in 1963), the American Institute of Electrical Engineers, the American Society of Mechanical Engineers, the Institute of Radio Engineers, and the Instrument Society of America. Abstracts and papers may be submitted through the member society headquarters with the designation "for 1963 JACC" or to the Program Chairman, Professor Otis L. Updike, Department of Chemical Engineering, University of Virginia, Charlottesville, Va. Early submission is urged. Further details on paper submission will be supplied after abstracts are received. The deadline schedule has been established to permit full preprinting of conference papers.

Papers prepared for the Congress of the International Federation for Automatic Control in Basle may be presented also at the JACC, and will be preprinted in abstract only to conform with IFAC requirements.

1962 Canadian Chemical Engineering Conference

C. I. C. — E. I. C.

Sarnia, Ontario — October 21-24, 1962.

Sunday, Oct. 21, 1962 – Coffee Party

Monday, Oct. 22, 1962 – 9:30 a.m. – TECHNICAL SESSION 1
Heat Transfer — Three Technical Papers
TECHNICAL SESSION 2 — General — Three Technical Papers

12:30 p.m. — Luncheon — R. E. McBurney, N.R.C. — Speaker

2:15-4:30 p.m. — Eight plant tours

2:15-4:30 p.m. — TECHNICAL SESSION 3 — Chemical Reaction — Four Technical Papers

Evening — Annual Dinner — Speaker

Tuesday, Oct. 23, 1962 – 9:00 a.m. – TECHNICAL SESSION 4
Heat Transfer — Three Technical Papers scheduled
TECHNICAL SESSION 5 — Caustic-Chlorine Technology — Three Technical Papers

11:30 a.m. — R. S. Jane Memorial Lecture — Dr. F. A. Forward

12:45 p.m. — Luncheon, Sarnia Riding Club — Speaker J. Newell

2:30 p.m. — TECHNICAL SESSION 6 — Mass Transfer — Four Papers
TECHNICAL SESSION 7 — Chemical Plant Maintenance — Four Technical Papers

8:15 p.m. — Report of the Chemical Engineering Division Computer Project — A. I. Johnson
— Joint Meeting with Sarnia C.I.C. Section
— Machine Computation for Chemical Engineers, A. I. Johnson

Wednesday, Oct. 24, 1962 – 9:00 a.m. – TECHNICAL SESSION 8 — Heat Transfer — Four Technical Papers
TECHNICAL SESSION 9 — Industrial Waste Disposal — Four Technical Papers

Noon — Informal Luncheon — Sarnia Golf & Curling Club

2:00 p.m. — TECHNICAL SESSION 10 — Industrial Development – Training and Trends – Four Technical Papers
TECHNICAL SESSION 11 — General — Four Technical Papers

FIRST NORTHWESTERN ONTARIO REGIONAL CONFERENCE

Port Arthur
Prince Arthur Hotel
December 7, 1962

9:00 a.m.—10:00 a.m.	Registration
10:00 a.m.—noon	Technical Session
Noon—2:15 p.m.	Lunch, Guest Speaker
2:30 p.m.—4:30 p.m.	Technical Session
5:30 p.m.—7:30 p.m.	Reception
7:30 p.m.	Dinner, informal
9:00 p.m.—1:00 a.m.	Dance

SKULE NITE 6T3

Presented
By The University of Toronto
Engineering Society

Hart House Theatre, Toronto

November 13, 14, 15, 16, 17

The 1963 version of this popular campus revue commemorates the 40th anniversary of the beginning of the show in 1923.

Some 50,000 persons have attended Skule Nite since 1923, and it is hoped many will return to rekindle the pleasant memory.

TECHNICAL PAPERS

FOR THE 1963 ANNUAL GENERAL MEETING

Members are reminded that they are invited to submit papers for presentation at the Annual Meeting in Quebec City, May 22-24, 1963. Deadline for complete manuscripts is January 31, 1963. (Ideal length is equivalent of 4 to 5 Journal pages.)

Abstracts or summaries of 400-500 words should be sent without delay to the appropriate C.T.O. Division Chairman listed below for his consideration in each case:

CIVIL ENGINEERING: Dr. R. M. Hardy, Hon. M.E.I.C., 10214-112th St., Edmonton, Alta.

BRIDGE & STRUCTURAL: A. M. Bain, M.E.I.C., c/o Dominion Bridge Co. Ltd., P.O. Box 280, Montreal, Que.

GEOTECHNICAL: Dr. R. F. Legget, M.E.I.C., National Research Council, Ottawa 2, Ont.

MINING & METALLURGICAL: Dr. R. P. Charbonnier, M.E.I.C., Senior Scientific Officer, Dept. of Mines & Technical Surveys, 562 Booth St., Ottawa 4, Ont.

CHEMICAL ENGINEERING: Dean G. W. Govier, M.E.I.C., Faculty of Engineering, University of Alberta, Edmonton, Alta.

MECHANICAL: Professor A. R. Edis, M.E.I.C., Department of Mechanical Engineering, McGill University, Montreal, Que.

WELDING: (No Chairman appointed as yet—send papers to Mechanical Division.)

THERMAL POWER: D. L. Harris, M.E.I.C., Chief Engineer, Mechanical Services & Thermal Division, Shawinigan Engineering Co. Ltd., 620 Dorchester Blvd. W., Montreal, Que.

HYDRO-ELECTRIC: J. A. Thomas, M.E.I.C., Shawinigan Engineering Co. Ltd., 620 Dorchester Blvd. W., Montreal, Que.

ELECTRICAL: A. J. Girdwood, M.E.I.C., Chief Engineer, Leland Electric Canada Ltd., Guelph, Ont.

COMMUNICATIONS, ELECTRONICS & AUTOMATION: Professor G. S. Glinski, M.E.I.C., Dept. of Electrical Engineering, University of Ottawa, Ottawa, Ont.

ENGINEERING EDUCATION: Professor A. Porter, M.E.I.C., Dept. of Industrial Engineering, University of Toronto, Toronto, Ont.

MANAGEMENT: W. L. Hutchison, M.E.I.C., Moffats Limited, Weston, Ont.

LETTER TO THE EDITOR

NEVER A DULL BENDING MOMENT

Dear Sir:

It occurred to me the other day—while oiling my slide rule, that in these days of stress, strain, plastic flaw and creep, a word or two (approximately) from a structural engineer, might lighten the load—even for a moment, for the architect and also perhaps, provide some enlightenment to the man in the street, who perchance might peruse these lines.

Most people don't know what engineers do.

Even more people don't know what structural engineers do.

Structural engineers are people who are neither qualified by training—nor by law—to design or build buildings by themselves. They are neither architects nor contractors.

But, here is what they do.

They surround space with material.

The size and shape of the space is determined by architects. That is what architects do.

The material enclosing the space or spaces must resist gravity and wind, with reasonable success.

People in all walks of life are affected, except those who inhabit houses. Houses are accustomed to stand-up on their own account—without the help of the beam and column boys.

Structural engineers are concerned, among other things—with floor systems (which in multi-storey buildings, occurs with more frequency than roofs)—the function of which are to support partitions and plumbing fixtures.

Ultimately, everything is connected to the earth's crust.

That is to say—all parts of a building that appear above the ground—are supported on what is below the ground—normally referred to as foundations.

The engineer's first step then is soil investigation. The traditional approach is to poke a slide rule into the bottom of a test pit—and measure the penetration. The figure thus obtained is inserted into a patented formula—which gives the phone number of a reliable soil consultant. However, aerial photography is now replacing this.

The footings or foundations are usually medium to large blocks—under the basement floor—which are intended to prevent undue vertical movement. The blocks are located more or less under uprights (technical nomenclature—columns) which are generally frowned upon by architects.

The columns carry other architecturally undesirable elements called beams or girders. Beams are small girders and vice versa, possibly.

To digress, architects prefer flat or beamless floors—or the "long span thin plate columnless system".

The three basic structural materials generally employed are described—very sketchily—below:

Reinforced Concrete: A material which exhibits an amazing tenacity to hold together in spite of everything.

Structural Steel: Sold by steel companies—easier to bolt together than concrete—and can also be reused later.

Timber: Satisfactory if kept out of stale air and fire—best under water.

A further explanation of the materials referred to above may be in order: Steel is well known to all. Timber is wood. Concrete is a mixture of water, cement, sand, crushed stone, all dried-up. Cement is a mysterious material—mostly sold in bags—which should not get wet. Reinforcing consists mainly of small round rods—embedded somewhere within the mass of the concrete—and placed, particularly by the impartial contractor, near the neutral axis. The reinforcing holds the cracked portions of the concrete together.

A word about plans

Firstly, architectural plans are blue prints—which by means of lines in two directions—generally show where nearly everything goes. Blue prints are cheaper than white prints—and also night courses concentrate mostly on "How to read blue prints".

Structural plans show what is eventually concealed by architectural materials—which is why nobody knows anything about structural engineers. However, structural drawings are referred to, occasionally, by what is known as a contractor.

The contractor is a man—or group of men—who conspire to successfully evade most of what is shown on the plans—particularly reinforcing steel.

A word about specifications.

Specifications—which accompany drawings—are a very boring written description of what is missing on the plans, and generally are not taken too seriously by the building trade. This has given rise to the "specifications writers association"—a dedicated body striving at least to be heard—if not read.

The structural specification however, is quite simple—and is usually confined to a note on the drawing, which specifies the age of the concrete at 28 days.

A brief reference to inspection.

The inspector is a man or group of men—engaged by the architect or engineer—but generally paid by the contractor to watch the contractor. Contractors resent criticism—and prefer the inspector who is understanding and forgiving.

Lastly, insurance.

This is something the architect, engineer and contractor buy—should what they plan and build, collapse, in which case, the insurance company hires an expert to prove it didn't.

The foregoing is an all too brief account of what structural engineering is all about—and anything that has been written should not be construed or interpreted in any way—and all references to the other professional conspirators, although inevitable, is unintentional.

This article may be quoted from in whole or in part—even though the writer may be jointly and severally responsible.

L. Shector, M.E.I.C,
Montreal

STUDENTS:

ATHLONE FELLOWSHIPS

Forty-one young Canadian engineers again will be selected this fall for two years of training in industrial establishments or universities in Britain under the Athlone Fellowships Scheme.

Selection Boards for the Awards will sit at 17 Canadian universities which grant degrees in engineering. The Boards will meet in October, November and December, with the first being held at Carleton University, Ottawa, October 24.

Information concerning eligibility, and application forms, may be obtained now from your Registrar.

It takes 5 years to throw the switch!

To research, design, construct, equip and produce electrical power requires time—usually about five years. But time alone builds nothing but a past—it takes time plus men, machines and materials to build and create power projects. Manitoba Hydro is people: people on the move researching better resources and better methods to help all of Canada grow and prosper...through electricity.

MANITOBA HYDRO

• Library Notes

(Continued from page 102)

NOUVEAU TRAITE DE MATERIAUX DE CONSTRUCTION, VOL. 1, 2 ED.

First volume of three of an extensive treatise on construction materials. The first three chapters cover basic properties of materials, building stone, and aggregates; the remaining 1150 pages deal with cements and concrete—their constitution, properties, and the general methods of use. Numerous tables and graphs add to the usefulness of the work. There is an extensive bibliography of mostly French references, and a detailed subject index by chapters. (M. Duriez and J. Arrambide. Paris, Dunod, 1961. 1491p., 225 NF.)

NON-DESTRUCTIVE TESTING OF CONCRETE.

This is a description of four methods of non-destructive testing of concrete: resonance, pulse, radioactive absorption, and hardness methods, with a discussion of the physical and experimental basis of each. The scope and limitations of each method and the relations between the measured quantities and the strength properties of concrete are emphasized. (R. Jones. Toronto, Macmillan, 1962. 103p., $4.25.)

AN ENGINEERING THEORY OF PLASTICITY.

In this translation of a Russian work, the author develops the principles of engineering methods for calculating deformation forces encountered in the principal processes of working metal by pressure. The first three chapters set out the physical principles of plastic flow, and analyze the basic factors affecting the course of the process of plastic flow, the structure of the deformed metal, and its mechanical properties. There follow two chapters devoted to the study of stress, while the last five set out the experimental basis of the suggested method and its application. (E. P. Unksov. Toronto, Butterworth, 1961. 275p., $14.)

TABLES FOR ULTIMATE STRENGTH DESIGN OF REINFORCED CONCRETE BEAMS JOISTS SLABS.

A set of ready-reference tables for the designers, to aid him in selecting the proper size and reinforcement for the conditions indicated by his own computations of moments and shears. The basic theories and derivations of ultimate strength design are briefly presented, with sample problems. Also included is an "ultimate strength wind formulas graph," with derivation. (James Cunningham and others. Jacksonville, CKNP Tables, 1961. 177p., $4.95.)

SEMICONDUCTOR DEVICE PHYSICS.

Those aspects of physics necessary to understand semiconductor devices are presented in a unified fashion. Specific topics discussed include quantum physics, thermostatics and statistical physics, energy bands and carrier statistics, the theory of junction devices, periodic structures and energy bands, irreversible thermodynamics, transport theory, and semiconductor parameters. (Allen Nussbaum, Englewood Cliffs, Prentice-Hall, 1962. 340p., $11.)

THE PLANNING AND DESIGN OF AIRPORTS.

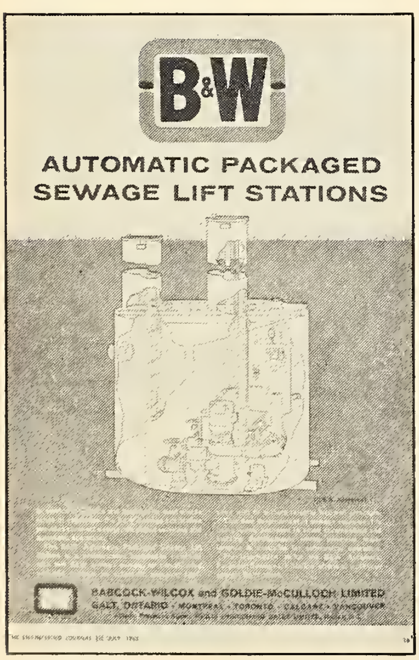
The various aspects of airport planning and design are covered, ranging from the nature of civil aviation to airport financing, airport site selection, landing areas, terminal areas, and lighting, Techniques for estimating volumes of passengers and aircraft are described, as are the function and operation of air traffic control. (Robert Horonjeff. Toronto, McGraw-Hill, 1962. 484p., $16.75.)

SYMPOSIUM ON ELECTRICAL CONDUCTIVITY IN ORGANIC SOLIDS.

This volume includes the papers presented at a symposium held at Duke University, in 1960. The papers cover a wide variety of topics, including charge-transport processes in organic materials, properties of aromatic hydrocarbons, photoelectric properties of semiconducting organic dyes, analyses of molecular crystals, chemical aspects of semi-conductive compounds, semiconductive properties of molecular complexes, and electric and magnetic properties of low-resistance organic semiconductors. (Ed. by H. Kallmann and M. Silver. New York, Wiley/Interscience, 1961. 398p., $12.50.)

EIC CERTIFICATE OF ADVERTISING MERIT

How do you find an interesting way of telling engineers you manufacture a prefabricated sewage lift station package, complete with pumps, air conditioning, controls and wet-wall structure? Babcock-Wilcox and Goldie-McCulloch Limited did it with a cut-away drawing imbedded in a green profile of the earth, complete with sprouting grass on top. And it was so successful it captured the Monthly Award as the best advertisement in the July issue of The Journal. The add is two-colour, full page, and is headed: "B&W Automatic Packaged Sewage Lift Stations". The B&W is a large use of the corporate logotype.



Each month a different panel of 50 Journal readers from across Canada is asked to select the award-winning ad from the viewpoint of ACCURACY-INFORMATION and ATTRACTION. Babcock-Wilcox and Goldie-McCulloch Limited advertising is produced by the Toronto office of Cockfield, Brown & Co. Ltd., C. W. McLeod, account supervisor, G. J. Rawnsley, account executive. Company advertising manager is V. A. Johnson. Agency and Company will both receive a framed certificate from The Journal.

SQUARE-LOOP FERRITE CIRCUITRY.

The discovery of ferrite materials with a rectangular hysteresis loop has aided in the development of high speed digital computers. It enabled the development of storage systems which were cheap, reliable and which made information available in microseconds. The author discusses the properties of square-loop ferrites, their use in coincident drive and word access storage systems and matrix and logical circuits. Ninety-two diagrams are included. (C. J. Quartly. London, Iliffe, 1962. 166p., 42s.)

APPLIED THERMODYNAMICS PROBLEMS FOR ENGINEERS.

This book was written to be used in conjunction with thermodynamics texts rather than to replace them. Each chapter deals with a particular aspect of thermodynamics such as combustion turbines, air compressors and gas laws, and works through problems related to the topic. At the end of each chapter is a set of problems with hints, intermediate steps and final answers. This book is useful for students with the prospect of an examination before them. (H. J. Peck and A. J. Richmond. London, Edward Arnold, 1961. 344p., $3.80.)

*VECTOR MECHANICS FOR ENGINEERS, PART II; DYNAMICS.

This is a profusely and well-illustrated text intended for use in the first undergraduate course in dynamics for engineers beyond the introduction to dynamics in the usual physics sequence. The topics covered include kinematics, particle dynamics, rigid bodies, and vibrating systems. Answers to the many problems are included. (Ed. by H. R. Nara. New York, Wiley, 1962. 434p., $6.50.)

*HEATING AND HUMIDIFYING LOAD ANALYSIS.

This work deals primarily with the accurate determination of the design load necessary for maintaining a selected temperature and humidity within a structure. For this purpose it provides a synthesis of the engineering techniques necessary to achieve an effective and economic system design. Climatological, human, and structural factors are considered as well as the applications of thermal engineering. The mathematical techniques for the analysis of heat and mass transmission, in both the steady and unsteady states, are developed and demonstrated. In addition, special problems such as those encountered in solar and panel heating are also treated. Comprehensive coverage of design data in convenient tabular form is included. (F. W. Hutchinson, New York, Ronald, 1962. 494p., $12.50.)

(Continued on page 128)

(Continued from page 127)

THE WAVE MECHANICS OF ELECTRONS IN METALS.

The basic principles of wave mechanics are developed from the fundamentals, and applications are given to simple one-electron systems, atoms, and molecules, as well as to the more complex problems of metals and other solids. Particular attention is paid to the calculation of energies—not only one-electron energies, but also the energy of the metallic system as a whole. (By Stanley Raimes. New York, Wiley/Interscience, 1951. 367p., $13.)

GEOLOGY AND ENGINEERING, 2ND ED.

The significance of geology in the execution of civil engineering projects is the main consideration of this book. Following a brief review of geological principles, the author examines the main branches of civil engineering from this point of view: tunnels and underground excavations; open excavation and dredging; earth movement and landslides; foundations of buildings, dams, and bridges; reservoirs and catchment areas; transportation routes; and marine works. Case histories are used to illustrate the principles involved. (R. F. Legget. Toronto, McGraw-Hill, 1962 884p., $12.50.)

THEORETICAL GEOMORPHOLOGY.

An advanced mathematical treatment of the surface features of the earth. The author describes briefly the physiographic facts of geomorphology, and reviews some of the basic physics necessary for the understanding of the subsequent exposition. He then gives in sequence such topics as the mechanics of slope formation, river bed processes, the dynamics of valley formation, the theory of subaquatic effects, and niveal effects. (A. E. Scheidegger. Englewood Cliffs, Prentice-Hall, 1961. 333p., $18.)

BUILDING CONSTRUCTION COST DATA, 20TH ED.

This manual provides average unit prices for industrial and commercial building construction items and is useful in making engineering estimates. The prices are based on United States averages for material and labor costs as of January, 1962. The first part is an alphabetical listing of materials with unit and installation costs, the second half contains breakdowns of these figures, descriptions, and notes on the best methods to be used in handling materials. (Ed. by R. G. Godfrey. Duxbury, Mass., Robert Snow Means Company, 1962. 138p., $3.50.)

*ELECTRONIC COMPUTERS: FUNDAMENTALS, SYSTEMS AND APPLICATIONS.

Written for those who have no special knowledge of computers, this book presents an over-all view of the various types. Subject areas covered are: computing control systems (basic principles, specific functions, design considerations, etc.), digital differential analysers (components, systems, sealing, speed, etc.), analog computers (components, the DC system, programming, design applications). Emphasis is placed on advantages and disadvantages of underlying principles rather than on specific machines or applications. (Ed. by Paul von Handel. Englewood Cliffs, Prentice-Hall, 1961. 235p., $13.50.)

VISUAL ART FOR INDUSTRY.

The author, industrial art director for the Hughes Aircraft Company, has written this book to describe the job of the industrial artist, and the place of graphic communication in modern industry. Half the book is concerned with technical illustrations, and covers drawing methods, freehand drawing, orthographic drawings, perspective, etc., and the various types of technical handbooks and manuals, and the ways of illustrating them. A chapter is devoted to the different types of charts and graphs, and their use in presenting statistical and non-statistical information, and another covers display charts, posters, slides for projection, movies etc., and a final chapter touches briefly on the printing and reproduction of art work. This book makes easy, and often entertaining reading, and is well illustrated. (George Magnan. New York, Reinhold, 1961. 176p., $13.75.)

(Continued on page 140)

EMCO

uses nickel to improve density and mechanical properties

"To assure our customers top quality products, we at Emco use only the finest materials and modern foundry practices and we add 1% nickel to our bronze castings to improve density and mechanical properties"

Emco Limited, London, Ontario

This chart illustrates how increased additions of nickel can help you broaden the scope of usefulness in a group of readily producible bronzes. For more demanding service, nickel additions in amounts of 3 to 8% produce properties, which are substantially greater than those obtainable from their lesser alloyed companions.

Pressure Bronzes in Common Use Alloyed with Small Amounts of Nickel

No.	Type	Application	Nickel	Copper	Tin	Lead	Zinc	Phos.	Tensile Strength	Yield Point	Elongation %	Bhn*
8	Fine grained	Pumps, valves, fittings, general purpose	1.50	83.50	5.00	5.00	5.00	0.02	38,000	17,000	34	73
9	High pressures	Pumps, valves, specialties	3.50	87.00	6.50	2.00	1.00	0.02	44,000	23,000	19	77
10	Very high pressures	Pumps, valves, speeialties	3.50	88.00	6.50	.50 max	2.00	0.05	49,000	23,000	48	86
11	High strength and pressures Ni-Vee L5-Z5	Pumps, valves, fittings, etc.	5.00	Bal.	5.00	5.00	5.00	0.05	40,000	20,000	20	80
11HT	Heat treated† Ni-Vee L5-Z5	Pumps, valves, fittings, etc.	5.00	Bal.	5.00	5.00	5.00	0.05	50,000	30,000	5	120
12	Moderate pressures	Pumps, valves, fittings	1.00	85.00	4.00	3.00	7.00	0.02	35,000	17,000	27	62
13	Moderate pressures	Pumps, valves, fittings	1.50	85.00	3.50	5.00	5.00	0.03	36,000	15,000	30	71
14	Good strength, pressures	Pumps, valves, water and gas fittings	2.50	Bal.	2.50	5.00	5.00	0.05	35,000	17,000	30	60
15	Low pressure (81 Metal)	Plumbing goods, miscellaneous	1.00	Bal.	3.00	7.00	9.00	0.05	29,000	13,000	18	55
16	Moderate pressure (81 Metal)	Plumbing goods, valves and fittings	3.00	Bal.	3.00	7.00	9.00	0.05	32,000	15,000	20	58
17	High strength (81 Metal)	Plumbing goods, valves and fittings	5.00	Bal.	3.00	7.00	9.00	0.05	35,000	17,000	25	60
18	Semi-red brass, Leaded	Plumbing goods, low pressure work	1.00	Bal.	3.00	6.00	15.00	0.02	25,000	12,000	15	35
19	Semi-red brass, high leaded	Plumbing goods, refrigerator and gas fittings, etc.	2.00	77.00	5.00	10.00	6.00	0.02	30,000	16,000	20	55

† Heat treatment: 5-10 hr. at 550° F., air eool.   * Brinell hardness obtained with 10-mm ball at 1000-kg load.

NICKEL ... *Its contribution is quality*

For further information write to

THE INTERNATIONAL NICKEL COMPANY OF CANADA, LIMITED, 55 YONGE ST., TORONTO 1, ONT.

• Library Notes *(Continued from page 128)*

MAGNETO-FLUID DYNAMICS, CURRENT PAPERS AND ABSTRACTS.

This, the first bibliography to be published under the auspices of AGARD, NATO, covers thoroughly the field of magneto-fluid-dynamics. It consists of over two thousand references, with abstracts being included for seven hundred of them. The references are divided into seven categories: magnetohydrodynamics (incompressible fluids), magneto-gas-dynamics (compressible fluids), magneto-fluid-dynamics, magneto-fluid-dynamic waves, plasma physics (particle approach), applied magneto-fluid-dynamics (aero-astronautical, geophysical, thermonuclear, etc.) and properties of conducting fluids. (Ed. by G. Napolitano and G. Contursi. Oxford, Pergammon Press, 1962. 251p., $10.00.)

TRANSISTOR CIRCUITS.

The fourth in this publisher's Basic Electronics Series, this volume explains transistor circuit operation clearly and simply. It covers simplified transistor physics; the three basic configurations, the common base, common emitter and common collector; oscillator circuits, amplifier circuits; detector circuits. For greater clarity, the circuits are printed in four colours. (T. M. Adams. Indianapolis, Sams, 1962. 136p., $3.95.)

***SHELL RESEARCH.**

A publication of the papers presented at a symposium held in 1961 at Delft, Netherlands. The scope of the symposium was chiefly limited to a consideration of experimental investigations on small or large models or on full scale shells executed in reinforced or prestressed concrete or in such other materials as timber, brick, steel, aluminum and plastic. Major problems considered included strength and stability under various loading conditions, influence of shape and edge conditions on stresses, influence of temperature changes and of the properties of the materials, effects of prestressing and prefabrication. The majority of the papers are in English. (Edited by A. M. Haas and A. L. Bouma. Amsterdam, North-Holland Pub. Co., 1961. 362p., 86s.)

***STRUCTURAL ANALYSIS.**

This volume is a unified treatment of the methods of analysis of statically determinate and indeterminate structures in both elastic and plastic conditions. It covers three-dimensional displacement geometry, compatibility, generalized stiffness, strain-energy methods, "frenum moments," three- and four-moment equations for frames with non-prismatic members and sideway, collapse or plastic methods, the generalized column-analogy equation and multiple rings, and the symbolic generalization of influence functions. (By L. Mantell and F. Marron. New York, Ronald Press, 1962. 423p., $10.00.)

***THERMAL ENVIRONMENTAL ENGINEERING.**

The principles of thermodynamics and heat transfer form the basis of this work which is concerned with methods of controlling the thermal environment. The thermal environment is defined as the composite influence of the surroundings upon the thermal equilibrium of the enclosed object. The scope of the book is indicated by the detailed coverage of thermoelectric cooling, solar radiation, the fundamental Mollier-type psychrometric chart, drying of materials, absorption refrigeration, cryogenics, psychrometry, heat transfer and mass transfer processes with moist air, and periodic heat transfer in building structures. In the two concluding chapters the author describes practical applications. (J. L. Threlkeld. Englewood Cliffs, Prentice-Hall, 1962. 514p., $16.00.)

°HIGH MAGNETIC FIELDS.

The 88 papers given at the MIT International Conference on High Magnetic Fields in 1961, and published in this volume, are grouped in four main sections: design of high-field solenoids and supporting systems; high-field research programs now underway at laboratories around the world; application of high fields in solid-state and low-temperature physics; and use of high fields in plasma physics. A considerable range of special-application fields is covered, including thermonuclear-fusion containment and space-vehicle shielding. References at the end of each paper constitute overall the most complete bibliography of the field yet compiled. (Henry Kolm and others. New York, M.I.T. Press and Wiley, 1962. 751p., $15.00.)

°COMPUTER CONTROL SYSTEMS TECHNOLOGY.

A unified, integrated treatment of computer control system technology. Many of the most recent theoretical advances are included, as well as many of the most important recent applications. The authors thus discuss system error analysis techniques for analog and digital computers, random processes in automatic control systems, guidance and control of aerospace vehicles, optimal control problems in discrete time systems, air traffic control, automatic machine tool control, optimalizing cruise control, and computer control in the process industries. (Ed. by C. T. Leondes. Toronto, McGraw-Hill, 1961. 649p., $18.50.)

°ELECTRONIC MEASURING INSTRUMENTS.

An introduction to electronic measurement and control as used in the laboratory and industry. Primary emphasis is placed on the function and use of the basic components employed in the measuring system. Basic test instruments most commonly used for the measurement of current, voltage, power, resistance, impedance, inductance, capacitance, and wave shapes are covered in associated groups. Electronic instrument systems which are used in counting, clinical measurements, simulation, and computation are then introduced and discussed. (H. E. Soisson. Toronto, McGraw-Hill, 1961. 325p., $8.75.)

°ADVANCES IN ELECTROCHEMISTRY AND ELECTROCHEMICAL ENGINEERING, VOLUME 1, ELECTROCHEMISTRY.

This volume is the first in a series intended to make available authoritative reviews in the area of electrochemical phenomena, and to bridge the gap between electrochemistry as a part of physical chemistry and electrochemical engineering. It begins with an account of recent work on double-layer phenomena and their correlation with electrode kinetics. Hydrogen overvoltage and oxygen overvoltage are then considered, and followed by discussions of two expanding areas of electrochemistry: semiconductors as electrodes and relaxation methods for fast electrode processes. (Ed. by Paul Delahay. New York, Wiley/Interscience, 1961. 326p., $12.00.)

°TREATMENT AND DISPOSAL OF RADIOACTIVE WASTES.

A broad survey of the problem of radioactive wastes which gives attention to many of the reeent developments. After discussing the origins of radioactive wastes, the question of chemical separation is considered from the viewpoints of waste treatment and of the recovery of potentially valuable materials. An account of the evaporation and storage of highly-active wastes is then followed by a description of the attempts which are being made to convert such wastes into stable solids for long-term storage. The disposal of solid wastes is next outlined, and followed by descriptions of low activity waste treatment and of the treatment of gaseous wastes. (C. B. Amphlett. London, Pergamon, 1961. 289p., $12.00.)

Consulting Services

Alchem LIMITED,
BURLINGTON, ONTARIO

Specializing in water treatment, petroleum inhibitors, fuel catalysts, papermaking chemicals and allied metallographic, microbiological and other services.

ASSOCIATED ENGINEERING SERVICES LTD.
Consulting Engineers

MUNICIPAL SANITARY INDUSTRIAL STRUCTURAL

Surveys, Town Planning, Reports, Supervision

REGINA	EDMONTON	VANCOUVER
1233 Winnipeg St.	12225-105 Avenue	2256 West 12th Avenue

BEAUCHEMIN — BEATON — LAPOINTE
CONSULTING ENGINEERS

Reports • Estimates • Design • Construction Supervision
for public works, municipolities, and industry

6655 COTE DES NEIGES ROAD MONTREAL 26, CANADA
REgent 1-8521

CANADIAN BRITISH ENGINEERING CONSULTANTS

Water Supply and Purification
Sewerage and Sewage Disposal
Treatment of Industrial Wastes
Harbour and Rivers Engineering

Toronto 19, Ont.	St. John's Nfld.	Halifax, N.S.
3089 Bathurst St.	325 Duckworth St.	513 Barrington St.

C. D. CARRUTHERS & WALLACE, CONSULTANTS LIMITED

92 Yorkville Avenue
Toronto 5

Consulting Structural Engineers

CARTIER, CÔTÉ, PIETTE, BOULVA, WERMENLINGER & ASSOCIÉS
Consulting Engineers

Hydro-electric Developments — Public Works
Railways and Highways —Soil Investigations — Surveys
Reports, Design and Construction Supervision
366 Lafleur Avenue Lasalle, Montreal 32, Que.
DOminic 6-2870

COODE, BINNIE & PREECE
Consulting Civil Electrical & Mechanical Engineers

Reports, Designs, Supervision, Docks & Harbours: Bridges: Water Supply & Drainage: Flood Protection & Irrigation: Sewerage Schemes: Hydro-Electric & Thermal Power.

36 Roxborough Apartments, Ottawa 4, Ontario
Telephone: Central 4-4674

G. E. CRIPPEN & ASSOCIATES LTD.
Engineering Consultants

Investigations, Designs, Supervision
Hydro Electric Developments, Water Supply Projects
Industrial Structures, Bridges, Dams, Electric Power
PHOTOGRAMMETRIC and AERIAL SURVEYS
207 West Hastings Street Vancouver, Canada

EDGAR A. CROSS & ASSOCIATES
Consulting Engineers

INDUSTRIAL PLANT DESIGN

2510 YONGE STREET, TORONTO HU. 1-1139

DE LEUW, CATHER & COMPANY OF CANADA LIMITED
Consulting Engineers

- Roads & Bridges
- Traffic & Parking
- Municipal Works
- Public Transit
- Railroads
- Harbours

TORONTO
OTTAWA ST. JOHN'S

DILWORTH SECORD MEAGHER & ASSOC.
LIMITED
Consulting Engineers

SPECIAL MACHINERY & EQUIPMENT, CONTROLS, RESEARCH FACILITY PLANNING, TURBO MACHINERY, NUCLEAR ENGINEERING, AIR POLLUTION.

Analyses • Experimentation • Design • Supervision

4214 DUNDAS ST. W. TORONTO 18, ONTARIO

V. DOLMAGE & D. D. CAMPBELL

Engineering and Mining Geologists
Foundations, tunnels, dam sites, ground water and mining.

1119 Marine Bldg. Vancouver, B.C.

Telephone: MUtual 5-9736
5-0936

Denotes Membership of a Principal in the Association of Consulting Engineers of Canada

Consulting Services

REMEMBER!
It's to your own
ADVANTAGE
to use
M.E.I.C. A.M.E.I.C. S.E.I.C.
in all your correspondence

Denotes Membership of a Principal in the Association of Consulting Engineers of Canada

INDEX TO ADVERTISERS

OCTOBER 1962

PUBLICATION OFFICES: The Engineering Institute of Canada, 2050 Mansfield Street, Montreal 2, Quebec, Canada.

Association of Consulting Engineers of Canada Incorporated

The following firms have principals who are members of this Association engaged as professional engineers in engineering work independent of salaried employment or sales promotion.

The revenue derived from the sale of advertising space assists the Institute in publishing THE ENGINEERING JOURNAL on a regular monthly basis. Listed above are the names of the Companies and individuals whose advertisements appear in this issue.

ADVERTISING OFFICES

QUEBEC: J. E. Donovon, Monoger, Advertising Sales. Representotive—Chorles R. Amey, 2050 Monsfield Street, Montreol, Phone: Victor 2-8121

ONTARIO: W. Morrison Doy, 160 Eglinton Ave. E., Suite 103, Toronto, Phone: 485-0789

WESTERN CANADA: W. George Turner, 501 - 191 Lombord Ave., Winnipeg, Mon., WH 3-9123

UNITED KINGDOM: H. A. Mackenzie, 4A Bloomsbury Squore, London, W.C.1, Englond. Phone: HOlborn 3779

EUROPE: Gustav Elm, 41 Avenue Montaigne, Poris 8, Fronce. Georg Linder, Wittelsbocher Allee 60, Frankfurt Am Main, West Germony.

NEW ENGLAND STATES: R. G. Melendy, 17 Maugus Avenue, Wellesley Hills 81, Moss. Phone: CEdor 5-6503

CHICAGO: W. Reynold Rotz, 549 W. Rondolph St., Chicogo 4, Ill. Phone: ST-2-8811

NEW YORK: John H. Boyd, 17 Eost 45th Street, New York, Phone: MUrroy Hill 7-0654

CALIFORNIA: Dunkle/Lehmon Company, 740 South Western Ave., Los Angeles, Calif. Phone: DUnkirk 7-6149

THE ENGINEERING JOURNAL

VOLUME 45 NUMBER 11 NOVEMBER 1962

LISHED MONTHLY BY THE ENGINEERING INSTITUTE OF CANADA, 2050 MANSFIELD ST., MONTREAL 2, QUE., CANADA • TEL. VI. 2-8121

Printed in Toronto

Price $6.00 a year in Canada, British Possessions, United States and Mexico. $7.50 a year in Foreign Countries. Current issues, 75 cents a copy, back issues from $1.00 per copy up. To members, affiliates and other bona fide engineers in Canada—no charge. Authorized as second class mail, by the Post Office Department, Ottawa, and for payment of postage in cash.

MEMBERSHIP

CCAB BNA

Indexed in
The Engineering Index
The Applied Science and Technology Index

CONTENTS

IN THIS ISSUE

In his paper, "*Ground Control Around Underground Openings*", **D. F.** Coates, M.E.I.C., presents a review for civil engineers of the pertinent developments in mining research and underground practices concerned with ground control. Developments during the past 15 years have improved the possibility either of preventing rock failure and excessive deformation, or of controlling these occurrences when they cannot be resisted. Rock mechanics is a new subject of research that is attempting to provide a scientific basis for understanding ground control problems. The principal areas of research within this subject are concerned with material properties as exhibited by both small size laboratory specimens and in a geological mass in-situ; the determination of actual stress distribution around openings and, the establishment of appropriate failure theories to permit the prediction of instability.

While the standard slide rule has long been considered as almost synonymous with engineering calculations, there is a rather widespread tendency to belittle its capabilities because of its inherent limitations. Since the slide rule is an analogue device, these limitations are real enough and must be respected. Within its field of application, the slide rule can be a superb instrument and capable of much more than the simple tasks usually given to it. **Dr. L. E. Jones**, M.E.I.C., Professor of Mechanical Engineering at the University of Toronto, in his paper, "***Some Unsuspected Capabilities of the Standard Slide Rule***", explores a number of the other-than-ordinary applications including use of procedural strategy to increase numerical accuracy, extension of the proportion principle, and the solution of polynominal equations of degree five or less. Professor Jones received a Ph.D. from the University of Toronto in 1941. He has been associated with the University since 1936 and in 1944 he joined the Department of Mechanical Engineering. He now is responsible for Department Division of Hydraulics and Fluid Mechanics and for departmental-digital calculation facilities. Professor Jones gives slide rule instruction annually to freshmen.

In their paper, "***Selection of Dyke Freeboard and Spillway Capacity for Grand Rapids Generating Station***", **I. W. McCaig** M.E.I.C., Director and Hydraulic Engineer; **F. H. Jonker**, Hydraulic Engineer and **W. Hamilton**, Project Engineer all of H. G. Acres & Co. Ltd., Niagara Falls, describe techniques used in computing the effects of waves on dykes of the Grand Rapids Generating Station, and show how the heights of the various dykes were adjusted to allow for varying conditions of exposure to wave attack. Meteorological studies of wind frequencies and hydrological studies of extreme floods were combined with an economic assessment of the risks of over topping of the dykes. These studies showed that it was necessary to make the dykes secure against the effects of storms and floods of a combined return period of 5000 years; that the effects of wind storms were the controlling conditions for the design of the dykes; and that economy of a spillway construction could be achieved by taking advantage of the differing seasons in which these phenomena are likely to occur.

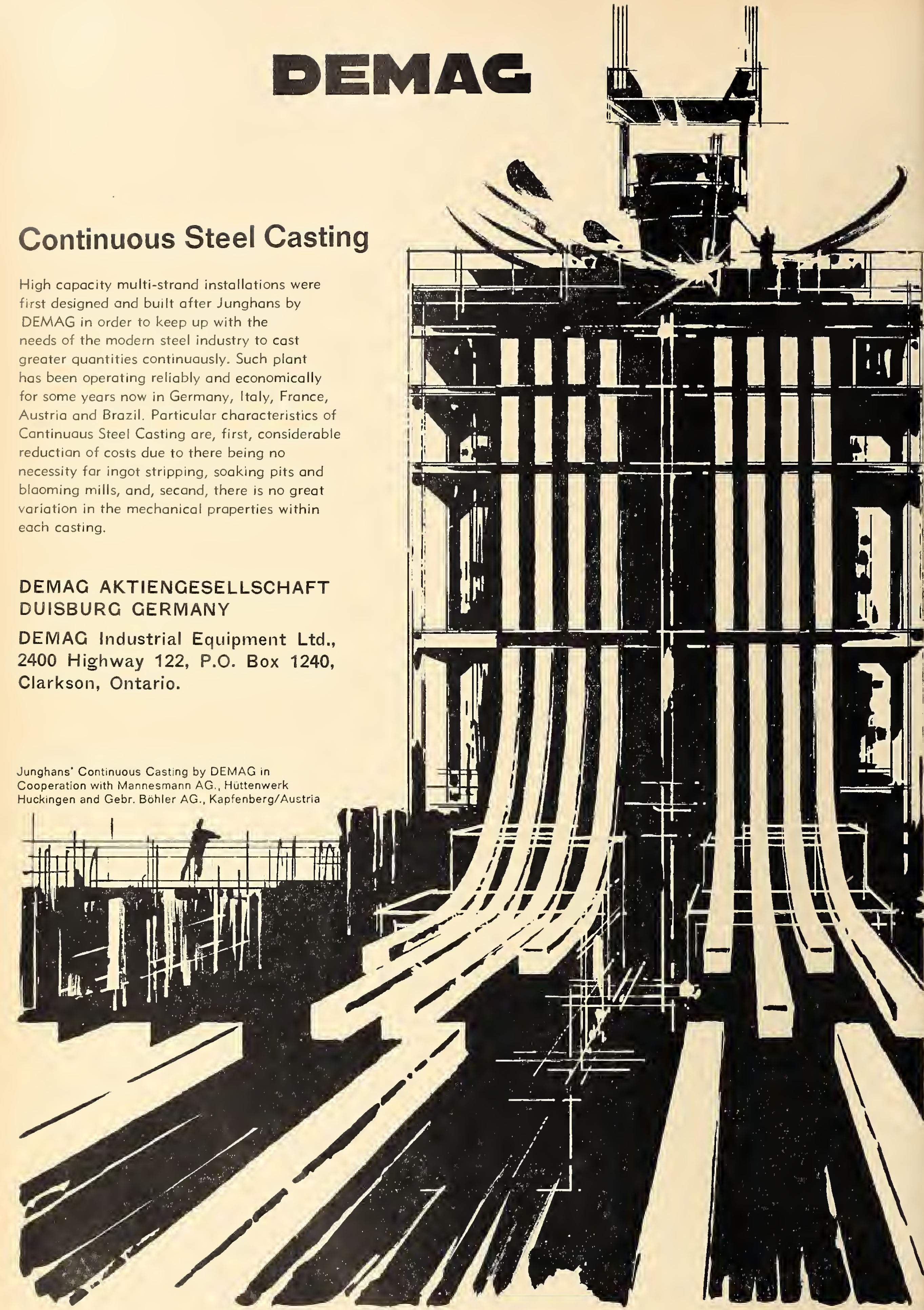
A. B. Hunt, M.E.I.C., Vice President, Research and Development, Northern Electric Company, Limited, states in his paper, "***Research and Development Objectives***" that half the work of research and development is carried out within industry where the ultimate motive is to increase profit for the shareholders. Industrial research must, therefore be objective. Some of the so-called research and product development carried out by Canadian companies is just another function of engineering, dominated by manufacturing. Reseaich to be effective, must have technical and financial freedom within authorized limits well defined by company policy. It cannot be turned on and off as company profits rise and fall, or diverted to meet cash production programs. To establish objectives, research must be aware of market requirements, current and future, as well as capabilities of manufacturing. A co-ordinated team representing marketing, engineering, manufacturing and research is therefore necessary to establish company policy. Research must justify its expenditures by increased company policy. With the huge sums being spent today by individual companies on research, top management must be fully informed well in advance of development programs and the possible effect on future manufacturing requirements and marketing methods.

G. E. Gunter, M.E.I.C., Mechanical Engineer, Design and Construction Division, New Brunswick Electric Power Commission, in his paper, "***Design and Construction Aspects of the Beechwood Third Unit***", describes the third and final unit as the Beechwood Generating Station on the Saint John River. The Unit, rated at 55,500 H.P. at a net head of 57 feet is somewhat larger than the existing two units. The governor for the turbine is of the electro-hydraulic type similar to those on units one and two. Investigations showed that efficiencies from the combination of the turbine and the existing draft tube were caused by an incompatibility between turbine and draft tube which manifested itself as a separation at the elbow of the tube.

J. E. Brett, M.E.I.C., of Brett & Ouellette, Consulting Engineers, Montreal, in his paper "***The Isolation of the Buildings in the Place Ville Marie Development from Railroad Induced Vibrations***", describes the design and installation methods used to counteract the effects of railroad-induced vibrations upon the various components of the project, including the Royal Bank of Canada Building. The paper also summarizes the techniques and results of the extensive field studies carried out to delineate the noise and vibration environment to which the structure is exposed.

COVER ILLUSTRATION

Shown is a drilling operation for a new crushing chamber in the Sullivan Mine of the Consolidated Mining and Smelting Company of Canada Limited, at Kimberly, B.C. Photo courtesy Consolidated Mining and Smelting Company Limited, Trail, B.C.


DEMAG
Continuous Steel Casting
High capacity multi-strand installations were first designed and built after Junghans by DEMAG in order to keep up with the needs of the modern steel industry to cast greater quantities continuously. Such plant has been operating reliably and economically for some years now in Germany, Italy, France, Austria and Brazil. Particular characteristics of Continuous Steel Casting are, first, considerable reduction of costs due to there being no necessity for ingot stripping, soaking pits and blooming mills, and, second, there is no great variation in the mechanical properties within each casting.
DEMAG AKTIENGESELLSCHAFT
DUISBURG GERMANY
DEMAG Industrial Equipment Ltd.,
2400 Highway 122, P.O. Box 1240,
Clarkson, Ontario.
Junghans' Continuous Casting by DEMAG in Cooperation with Mannesmann AG., Hüttenwerk Huckingen and Gebr. Böhler AG., Kapfenberg/Austria

GROUND CONTROL AROUND UNDERGROUND OPENINGS

D. F. Coates, M.E.I.C.

Professional Research Engineer

THIS PAPER is a review for civil engineers of the pertinent developments in mining research and underground practices concerned with ground control. Developments during the past 15 years have improved the possibility either of preventing rock failure and excessive deformation or of controlling these occurrences when they cannot be resisted. In addition, although not of interest to the civil engineer, those in mining have improved their ability to cause failure and flow conditions for purposes of extraction.

Rock mechanics is a new subject of research that is attempting to provide a scientific basis for understanding ground control problems. The principal areas of research within this subject are concerned with: (1) material properties as exhibited by both small size laboratory specimens and in a geological mass in-situ, (2) the determination of actual stress distributions around openings, and (3) the establishment of appropriate failure theories to permit the prediction of instability.

The principal underground openings that civil engineers are concerned with are tunnels for various purposes and in some cases large chambers for power houses. For the mining engineer a tunnel or drift is a relatively simple opening compared with those that are created for actual mining operations. This means that in mining, more complex stress

distributions and generally more difficult geological conditions are encountered. A third area has developed from the recent need for placing defence installations underground. The degree of complexity of these openings are somewhere between those normally experienced by civil engineers and those which the mining engineer must handle.

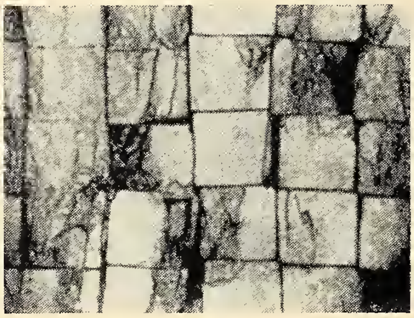
Besides these technical differences between the various fields involved in underground work, it is intriguing to examine the differences due to organizational frameworks. Without going into details it seems clear that the major incentives for engineers working in these various fields are somewhat different. The mining engineer is very concerned with costs and safety, but is willing to work towards these objectives over a period of time. The civil engineer working in the construction aspect of underground installations is also concerned with minimum costs and safety, but, considering the variety of jobs which any one contractor must handle, he is generally not able to work towards these objectives over a long period of time, having to achieve the best that is possible on a job basis. The civil engineer working in design, although concerned with costs, is probably most concerned with designing a safe installation. Again, his orientation generally is on a job basis rather than being able to work towards optimum objectives during a period of time.

Hence the incentives for research and development to improve methods seem to be stronger and more direct in the mining industry than in the construction industry. One example of how these differential incentives produce different results can be seen in the operation of drilling and blasting. Most mining operations include studies, if not research, on this subject, whereas there are very few owners of civil structures, consulting engineer designers or contractors who are doing any research in drilling and blasting. In the case of those involved in the heavy construction industry no one group seems to have strong long-term incentives to provide the money for these kinds of applied research.

Before proceeding with the details of some of the information that is available in this field, it is useful to have the differences between soil and rock established. As a structural material, rock differs from soil in two respects: (1) rock strengths are of a higher order of magnitude than soil strengths; (2) rock formations are seldom found that form comprehensive masses similar to cohesive soils, i.e. rocks almost always contain a family of joints, not to mention the possibility of other structural features, which divide the mass into a system of blocks. The effects of bedding, schistosity, etc., can be considered analytically as being additional complexities super-imposed on this block system.

The blocks of a rock mass may or may not be cemented together. However, the strength of the cement between the blocks is normally less than that of the blocks themselves. Figure 1 shows a block mass subjected to stress. From the reaction of the individual blocks it can be appreciated that a mass of such blocks could not be expected to behave like a comprehensive body.

Fig. 1. A mass of Rock Block Subjected to Pressure (19).



This concept suggests the following definition for rock masses: "a body made up of bloeks joined together with a cement that is weaker than the block material and having a zero void ratio". When the strength of the cement is equal to the strength of the block material the mass would behave like a cohesive coil. When the elements are too small to be considered as blocks, possibly six inches minimum, and the void ratio is greater than zero, the mass would behave like a granular soil. Recognizing these differences it can be appreciated that the methods established for use in soil mechanics are not necessarily applicable to rocks.

Another aspect of the differentiates the fields involved with underground openings. Underground installations in the fields of civil engineering or defence are generally permanent. Hence they cannot be treated exactly like mining openings. For example, scaling of walls and backs may not be possible after the installation is completed; rehabilitation and replacement sets in deteriorated sections generally is not possible; support such as rock bolting must resist corrosion. Also, the shape of the openings cannot normally be modified after the nature of the ground reaction has been experienced.

STRESS DISTRIBUTION

The distribution of stress around an underground opening is based primarily on elastic theory. The variation of stresses and their magnitudes, based on this theory, for the various shapes of openings has been well established.[1]

Many rocks, of course, do not behave in an elastic manner. However, aside from the fact no other theory is yet as serviceable, use of elastic theory has some justification. Other types of ground reaction, e.g. visco-elastic, plasto-elastic, elasto-plastic, can be considered as modifications of the answer obtained from the elastic solution.

The analyses for these other idealized materials, whenever they become possible, must still include the same equilibrium equations and boundary conditions. The compatibility equations will be different. Hence the elastic solution can always be considered as a first approximation and, if necessary, extrapolation can be by judgment. At the same time, in some situations such as plastie theory that has been established is quite useful.[2]

Figure 2 shows some typical stress distributions around a tunnel in a gravitational stress field. In Figure 2a the variation of the tangential stress (i.e. the stress parallel to the surface of the opening) around a tunnel, assuming elastic ground, is shown. The maximum values occur on the sides and the minimum at the crown.

In Figures 2b the variation of both the tangential and radial stresses in the sides with distance into the ground is shown. It can be seen that a rapid decrease occurs in the surface value of the tangential stress to the field value. The radial stress must be zero at the surface, if the tunnel has no lining, and hence rise for the field value.

In Figure 2c the case shown where the stress at the surfaee of the tunnel has exceeded the strength of the ground. Hence stability can only be achieved with some method of ground support. If a lining is provided the stress pattern within the failed zone (e) follows plastic relations and then beyond (e) is transformed into elastic relations. The zone (f) indicates the probable failure zone taking into account the probability that not all the failed ground is contained. Any loss of this material, such as is most likely to occur in the roof, will permit the failure zone to be extended from (e) to (f).

In Figure 2d the interaction of twin tunnels is shown. Whereas for a single tunnel the maximum stress only applies to a thin annular layer, for twin tunnels, when close enough, the maximum stress can act on the entire pillar between the tunnels.

In Figure 2e the vertical stress that would exist over a series of three tunnels is shown. The transfer of stress into the abutments and pillars accounts for the pattern shown here. This pattern could be expected to apply in both elastic and plastic ground.

The original stress field existing in the ground before an opening is made determines, to a large extent, the ultimate stress distribution around the opening. The surrounding ground must support the stress formerly resisted by the excavated material. Vertical stress, unless seriously modified by geological structure, can generally be assumed to be equal to the weight of the overburden.

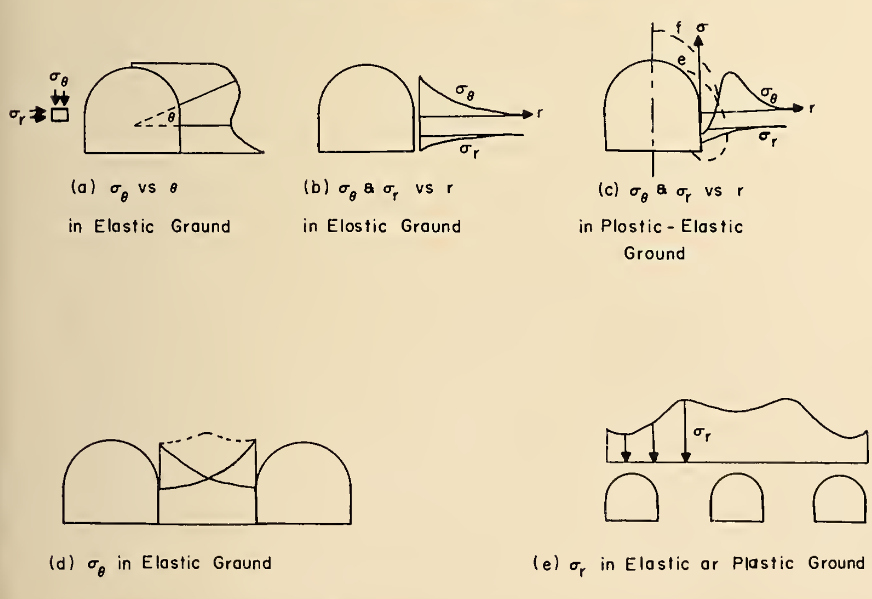
The horizontal stress in rock may be due simply to confinement of rock in the horizontal direction resisting the tendency to expand owing to vertical gravitational stresses. In this case, the horizontal stress in brittle rocks would be related to the vertical stress through Poisson's ratio. In less competent ground the horizontal and vertical stresses may be related through plastic parameters.[2]

However, the probability exists that a great deal of the ground in which underground openings are placed will be affected by organic action which could produce a horizontal stress greater than the vertical stress. In this case, the field stress is theoretically indeterminent and must be measured in the field. Some measurements have indicated that in a few locations the horizontal stress was about 50 per cent greater than the vertical gravitational stress[16]

Various methods are being developed for the measurement of field stress. Gauge points have been socketed in the rock face and their distance apart measured accurately before and after the surrounding rock is cut free from the formation.[3] Another technique is to measure very accurately the deformation that takes place in a bore hole when, by overcoring, the surrounding rock is disengaged from the formation.[4] Other techniques involving the trepanning of the rock around a bore hole have also been tried.[16] The use of photoelastic reflective coatings is a new technique that may turn out to be useful for the determination of field stresses.[6, 7]

Geological factors can affect significantly the stress distribution around mining openings. Structural conditions such as nearby faults or dikes can produce local variations in the field stress resulting from lack of constraint of the rock in the direction parallel to the fault. This has resulted in ground failure around openings that were otherwise stable. In addition, it would not be unusual if the superincumbent loads which had previously existed, as well as the variations in temperature, had provided a legacy of built-in stresses that would explain many of the hitherto puzzling cases of ground failure. These factors reinforce the conclusion that field stress measurements are important.

Fig. 2. Stresses around Tunnels



Whatever the nature and source of field stress, the result is that this stress is concentrated around the underground opening. A compressive stress two to three times the field stress is thus created in adjacent ground. In addition, when the field stress in one direction is less than about a third of the maximum field stress at right angles to it, tensile stresses will be created in the ground on the axis parallel to the direction of this maximum stress. As rock masses are generally weak in tension such a resultant stress is likely to cause loose ground.

The presence or absence of tensile stresses can also be influenced to some extent by the shape of the opening.[1] For example, in the same stress field a circular opening could have a compressive stress whereas a square opening would have a tensile stress.

STRENGTH FACTORS

For the analytical appraisal of potential failure or excessive deformation it is necessary to have a quantitative measure of the physical properties of the rocks. This, of course, assumes that all the pertinent geological information has been gathered and that the rocks have been classified according to their petrology and stratigraph. The objective then is to be able to predict the reaction of the rocks surrounding the underground opening when subjected to the extra stresses created by the opening.

The determination of the deformation and strength properties in compression, and thus also in shear, is not straightforward. Methods established in the field of concrete control were largely adopted in rock mechanics. However, it has been found that for rocks the results can be very sensitive to the test conditions. For example, it is quite common for rock samples tested in uniaxial compression to actually fail in tension axial planes.[9, 10]

Also, the absolute size as well as the shape of samples have been shown to be very significant.[10, 18] The strength of most rock samples decreases with an increase in size and with an increase in length to width ratio. However, some rocks have shown the reverse effect.

Triaxial testing, although expensive, is being increasingly recognized as important to eliminate some of these unrepresentative effects.

The tension testing of rocks has also been found to be very sensitive to the state of the sample and test conditions. Uniaxial and beam tests have been tried but are not considered perfectly satisfactory. It is

difficult with these tests to obtain results that do not have a high dispersion. A simple method, the Brazilian test, has recently been developed which seems able to produce consistent results. This method only requires the application of a diametral force to a disc of rock cut from diamond drill cores.

When the testing of laboratory samples has been satisfactorily accomplished it is then necessary to relate these properties to those of the rock formation. Here it is important to recognize the importance of the geological structural features as well as the basic blocky nature of a rock mass. Besides the normal geological techniques for determining structural details other methods of probing for planes of weakness using geophysical methods are being developed.[11]

The use of test results on any material usually requires the extrapolation of this information through a strength theory to the various combinations of stress that might exist in the structure to be designed. In rocks there are two theories which are considered to have some validity; Mohr's theory and Griffith's theory. It may turn out that other theories are more applicable; however, there is little empirical data as yet on which to make a suitable selection. At the moment, such information as exists indicates that Mohr's theory has some validity.

On the other hand, Griffith's theory, which conceives of failure as the result of the formation or elongation of existing cracks in the material, conceptually has much to recommend it. Furthermore, the finding of an element of plastic strain in many otherwise brittle rocks supplies some evidence to support this theory. Actually, in the mathematical extrapolation from test results to prototype situations both Mohr's and Griffith's theories give similar answers.[21]

In addition, the residual effects of blasting must be recognized. The partition of the explosive energy between the broken and the solid rock is such that large forces are applied to the unbroken face. These forces actually cause internal damage which results in the development of loose surface rock.

It is sometimes possible to reduce the damaging effects of blasting and at the same time not incur extra costs. For example, more destructive force is transmitted into the remaining ground when blast holes drilled perpendicular to the face are used than when holes drilled parallel to the face can be used. Also, recently developed smooth-wall blasting techniques have been shown to reduce the damage to the remaining faces, reduce the cost of scaling loose rock from the backs and walls and hence increase the advance per shift of the same crew.

When numbers have been selected for maximum stresses and strength, it remains to be questioned whether ground will fail under stress concentrations. Considering the infinitesimal thickness of ground which is subjected to the maximum stress it is possible for minor deviations from perfect elasticity to modify significantly the stress distribution. In one case it seemed that the stress concentration required to produce failure was 10 per cent greater than the loading required to produce failure on a normal sample, whereas in another case, the theoretical stress concentration had to exceed the strength by 100 per cent to 200 per cent before failure occurred. One explanation of these phenomena is the possibility of relaxation of surface tangential stresses (Fig. 2). The actual occurrence of this phenomena has been demonstrated.

DEFORMATION

It has been suggested that rocks should be considered as rheological materials. In other words, it should be recognized that the strain occurring in rocks at a constant stress level can increase with time; similarly, the release of strain on the release of stress may include an instantaneous component but probably also includes a component that takes time. Of course, with the wide variety of rocks in existence the time dependent elements of strain may be insignificant in very hard brittle rocks; whereas, the time dependent strain might comprise the major part of the total ultimate strain for other less competent rocks.

To predict the amount of deformation to be expected as a consequence of excavating rocks from a tunnel or chambers, it is necessary to study these rheological properties. Some rocks will produce an insignificant deformation or shortening of the diameter of the tunnel. On the other hand, in rocks where yield can occur without rupture, the deformation can be more significant and may either come to equilibrium at some ultimate value, or continue to creep at some ultimately constant rate. Clearly, it is important to determine which type of ground reaction to expect when establishing the rock pressures that are to be used in the design of the lining together with the selection of the type of lining to be used.

Deformation as a consequence of failure and expansion of the surface rock from its solid state into a fractured state with a higher void ratio must also be considered. As mentioned earlier, situations can exist where such fractured ground should be contained so that a build-up of back pressure to achieve stability in the rock against continuous failure can be obtained. (Fig. 2)

In some cases deformation will be the combination of all these possible mechanisms: instantaneous elastic strain, time dependent strain without fracture and strain consequent on fracturing. In this case, it would be difficult to prediet with any degree of accuracy deformation-pressure relationships. Approximations could be made as a result of analysing all components; however, it is more satisfactory to be able to make field measurements to establish these relationships before the final design of the support system is made. This procedure has been shown to make it possible to predict deformations with a high degree of accuracy.[12]

Figure 3 shows a strain-time curve for a typical rheological material — in this case a hard clay. This figure also shows some of the various rheological models that might represent different rocks.

The Maxwell model would represent a material which would give an immediate strain on the application of stress followed by an increase in strain which would continue indefinitely. On the release of strain there would be an immediate recovery of some strain but the strain that had been time dependent would not be recovered.

The Kelvin model would represent a material that would have an insignificant amount of instantaneous strain on application of stress. However, with the passage of time, strain would occur but at a diminishing rate until equilibrium had been reached. On release of stress in the Kelvin model, there would be an insignificant decrease in strain; however, with the passage of time all the strain would be recovered.

The General Linear model probably comes closer than the preceeding models to representing the reaction of many rock types. In this case, there would be an immediate strain on application of stress followed by a time dependent strain which would occur at a decreasing rate until equilibrium had been reached. On release of stress there would be an immediate regain of some of the strain followed by a time dependent regain of strain again at a rate that would be decreasing with time.

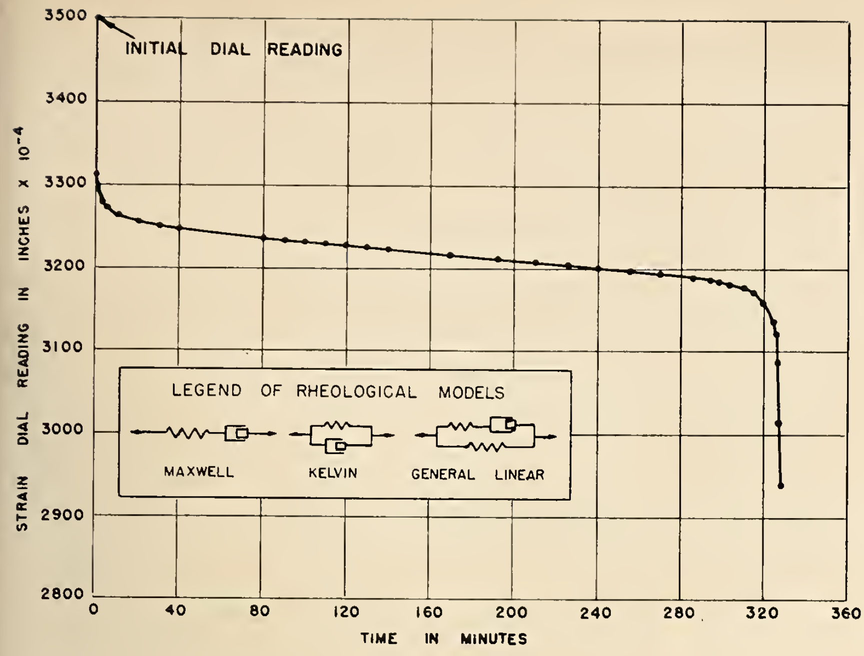


Fig. 3. Typical Strains vs Time Curve

The actual strain-time curve as shown in Fig. 3 indicates a General Linear material. There was an immediate strain from the dial reading of 3500 to about 3310. A time dependent strain then followed to a dial reading of about 3220. At this point there was an inflection in the curve indicating an increase in strain rate which ultimately accelerated to produce failure.

In mines it is not unusual for minor adjustments to the new stress conditions created by an opening to continue for months after the excavation has occurred. Indeed, there is some evidence to indicate that complete equilibrium need not be reached around large openings except after a period of years.

GROUND SUPPORT

Mass concrete might be considered for lining an opening. Where rock pressures are expected to be low, where loose ground is expected to develop, where a formal lining is required for architectural or fluid flow reasons this type of lining is useful. It is one of the cheaper lining methods but is not particularly strong against high pressures or differential pressures.

Reinforced concrete might be used in the same cases cited above for mass concrete linings. In this case, the need for reinforcing might arise from a large differential rock pressure producing tension in the lining. It might also be needed merely to add compressive strength to the lining where the thickness of concrete is limited. This tends to be an expensive lining.

Timber sets or steel sets together with timber lagging might be considered. In this case, in a civil engineering project, provision generally would have to be made to prevent corrosion of the steel and rotting of the wood. This type of lining is seldom practicable for a permanent installation owing to its high expense.

The remaining method of lining or supporting an underground opening is by the use of patterned rock bolting. It has been demonstrated that a mass of unconnected rods can be made into a beam by transverse bolting.[15] Thus it is reasonable to assume that the same thing can be done more easily with fractured rock. In other words, rock bolts under tension should not only inhibit failure of walls and roofs by keeping joints tight, but should also be able to knit a mass of failed loose rock into a beam that can support itself.

To insure long-term stability of such a support system, it is essential that the bolts be grouted. In addition, a wire mesh or some such membrane should be used to support the loose rock that can develop between the bolts. Not only can such loose rock cause considerable damage in falling, but can also jeopardize the support of the individual bolts by the ravelling action that could otherwise occur up to and around the washer and the bolt.

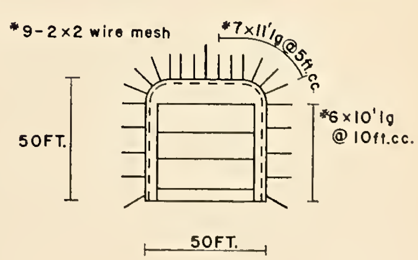
Figure 4 shows a system that was designed for long-term ground support for a large chamber that was to be subjected to high ground stresses. In this case, the patterned rock bolt and mesh lining system was found to be considerably cheaper than other methods of lining the large opening.

Experience has shown that generally it is preferable to install such rock bolts as soon as possible. This can be done immediately after the muck has been excavated from a blasted round. In this case, as well as in general, it is essential that the bolts be tightened and checked several times before it is assumed that a solid non-creeping anchorage has been obtained. The possibility of such anchorage not being obtained with grouted rock bolts is much less likely than with the normal ungrouted bolts.

On the other hand, in ground that produces a deformation that is strongly time dependent, e.g. a General Linear body, it may be preferable to install a temporary yielding lining before a permanent lining is placed. In other words, if a rigid lining is placed before the time dependent strain has occurred, some very high and almost irresistable pressures could be exerted on the lining. In such ground, yielding steel arches for mining purposes have proved to be very sucessful. However, for a permanent lining in a civil engineering project, they may not be feasible. On the other hand, a hard look in such circumstances at the requirements of the lining and the maintenance that could be supplied might result in selecting such arches for the support system.

In this regard it is interesting to examine the optimum cross-section for steel supports to resist rock pressures. The civil engineer's normal reaction would be to use a wide-flange section, where the maximum bending capacity is obtained for a given weight of steel. However, in the case of ground support members the application of the load in the axial plane of the wide-flange section cannot be guaranteed. Consequently, it is a common sight to see such members when used underground with buckled flanges and buckled webs and with a very much reduced supporting capacity.

Fig. 4 Ground Support System



Tests have shown that when beams are loaded by a force which is not held laterally that other sections are more stable under conditions of high deformation than the wide-flange section.[15] These sections are thus used in steel arches and rings that are designed for the purpose of providing ground support against rock pressures.

DESIGN

In designing underground openings and their support systems, the traditional approach of the civil engineer in using standard permissable stresses should not be adopted. For one reason, it is impossible to determine the precise strength of most rocks; indeed, we should expect such materials to have a variation in strength with some statistically determinable distribution about a mean value. Hence design should be based on the probabilities involved in the loading conditions and in the strength of the materials.

There is a good argument for using the probability relations underlying all engineering design in an explicit manner. At the moment it may be difficult to follow such a procedure rigorously throughout the entire design. However, it is thought to be useful to think in terms of this type of theory so that advances can be made in the right direction and overdesign and excessive expense can be minimized.

Otherwise, the design procedure follows the normally civil engineering method. It is necessary to predict the stress distribution that will occur in both the surrounding ground and in the support system that is adopted. The strength of the rock under the various stress conditions that might occur is then to be determined and compared with the maximum stresses that might occur. An appropriate safety factor is usually required against stresses exceeding strength.

To select the appropriate safety factor against rock failure it is suggested that a procedure somewhat as follows be used. On the basis of an array of laboratory test results, the coefficient of variation should be determined. Then it could be assumed that a safety factor of more than 1 should apply to the maximum load and to the minimum strength. The minimum strength could be defined as the level at which 99 per cent of the tests show greater strengths. This minimum strength could then be related to the average strength and the safety factor obtained in this way compared with the safety factor normally used.

For example, if the coefficient of variation were 20 per cent, then a safety factor of little more than 1 on the minimum strength (as defined above) would be equivalent to a safety factor of 2 on the average strength; or for a coefficient of variation of 30 per cent, the equivalent safety factor on the average strength would be 3. These figures can then be compared with safety factors used in typical structural engineering practice, e.g. for bearing pressures in concrete a safety factor of about 4 on a specified strength such that 80 per cent of the test results should provide greater strengths than the specified ultimate strength would be equivalent to a safety factor of about 5 on the average strength. There is no reason why safety factors throughout should be equal; however, they should be consistent and reflect the probability of loads or stresses in excess of those used in the design.

The usual civil engineering design procedure requires simplified hypotheses regarding both materials and structures. Even when such hypotheses are made, unless the prototype structure is essentially truly simple the resultant mathematics is often formidable to the extent of being impractical. In structural engineering, theoretical analysis has been an eminently useful tool as a result of most of the struetural elements being essentially quite simple (e.g. beams and columns) and the materials being actually quite similar to the simplified assumptions (e.g. steel and concrete at working stress levels being close to perfectly elastic materials). As structures have become more complex, e.g. multi-bay rigid frames, shells, two-way arches, the service provided by a theoretical analysis has diminished. The computer has extended its use on some of these structures, others are being designed (e.g. two-way shells) largely on intuition. In the place of intuition or very proximate analysis some organizations are using structural model studies.

In another branch of civil engineering — soil mechanics — the physical forms are less simple than in structural engineering and the materials cannot be represented by simple hypotheses with as much validity. Nevertheless, theoretical analysis has been a great service in this field as some of the physical forms could be represented by moderately simple hypotheses in two dimensions, and as deformations have been largely ignored with the assumption of perfectly plastic material. In other words, design has been based largely on strength criteria. Where deformation has been important and where the physical forms require analysis in three dimensions the methodology has been less successful. Hence again for important problems model studies have been used.

In rock mechanics both deformation and strength are important. In addition, the structures often cannot be closely represented by simple hypotheses, and the materials often cannot be represented by ideal prototypes. It is to be expected, therefore, that theoretical analysis will not produce the same results as in structural engineering or soil mechanics. Consequently, there are many cases where model work might be an alternate procedure for predicting stresses, strains and the consequence of these reactions around underground openings.[20]

References

1. Obert, L., "Design of Underground Openings in Competent Rock" USBM, Bull 587, 1960.
2. Fenner, R., "Researches on the Notion of Ground Stress" Gluckauf, August and September, 1938.
3. Tincelin, E., "Research on Rock Pressures in the Iron Mines of Lorraine (France) International Conference on Rock Pressure and Support in Workings," Liege, 1951.
4. Merrill, R., and Peterson, J., "Deformation of a Bore Hole in Rock" USBM RI 581, 1961.
5. Buchanan, J., "The Load Cell Installation in the No. 3 Mine Dominion Wabana Ore Limited, Belle Island, Newfoundland", Mines Branch, PM 194, 1955.
6. Zandman, F., and Wood, M., "Photostress, a new Technique for Photoelastic Stress Analysis for Observing and Measuring Surface Strains on Actual Structures and Parts", Product Engineering, September, 1956.
7. Emery, C., "The Photoelasticity Technique of Studying Rock Strains", Annual Meeting Canadian Institute of Mining and Metallurgy, 1962.
8. Muller, L., "The European Approach to Slope Stability Problems", Quarterly Colorado School of Mines, Vol. 54, No. 3, 1959.
9. Kvapil, R., "Concerning the Theory of Rock Destruction", International Strata Control Congress, Leipsig, 1958.
10. Tun, H., "Elastic and Strength Properties of Elliot Lake Quartzite", unpublished Master's Thesis, McGill University, 1961.
11. Morgan, C., and Miller, T., "Use of Sonic Techniques in Exploring Coal-mine Roof Strata: A Progress Report" Proc International Symposium on Mining Research, University of Missouri, 1961.
12. Schwartz, B., "Movements of the Rock and Floor in Roadways", Proc 4th Symposium on Rock Mechanics, Penn State University, 1961.
13. Hardy, H., "Time Dependent Deformation and Failure of Geologic Materials", Quarterly Colorado School of Mines, Vol. 54, No. 3, 1959.
14. Zeppernick, G., "Mine Roadway Supports Under Difficult Conditions", Journal Leeds University Mining Society, Vol. 37.
15. Lang, T., "Theory and Practice of Rock Bolting" Trans AIME, 1961.
16. Hast, N., "The Measurement of Rock Pressure in Mines", Swedish Geological Survey, ARSBOK 52, 1958.
17. Morrison, R. G. K., "Notes on a Rockburst in the Ooregum Mine", Kolar Gold Field Mining and Metallurgical Society Bull. No. 33, Vol. 6, 1932.
18. Skinner, W. J., "Experiments on the Compressive Strength of a Anhydrite", The Engineer, Feb. 13 and 20, 1959.
19. Venter, J., and Stasse, P., "Pressure and Movement in Soft Rocks", International Strata Congress, Leipzig, 1958.
20. Ruppenheit, K., "Experience Gained in the Application of the Theory of Dimensions for Determining Roof Displacements in Faces, Taking the Time Factor into Consideration", International Strata Conference, Paris, 1960.
21. Clansing, D. P., "Comparison of Griffith's Theory and Mohr's Failure Criteria", Quarterly Colorado School of Mines, Vol. 54, No. 3, 1959.

Some Unsuspected Capabilities of the Standard Slide Rule

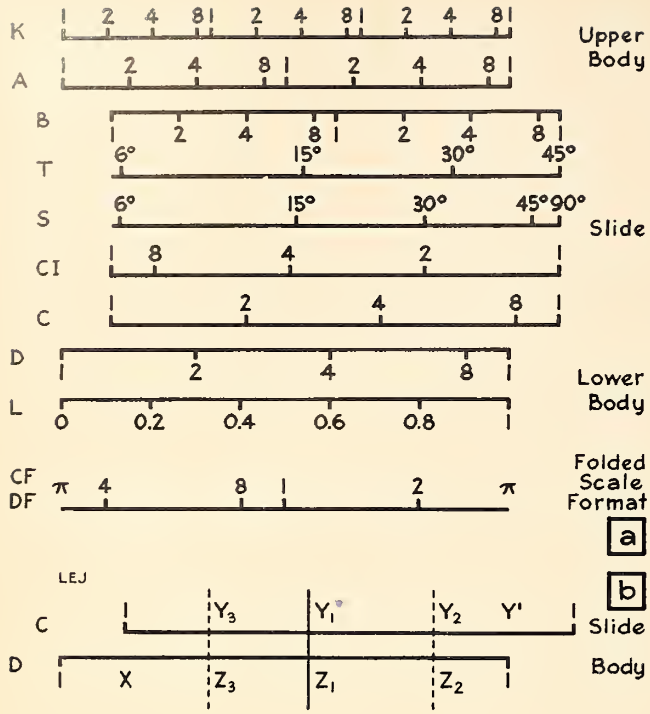
L. E. Jones, M.E.I.C.
Professor of Mechanical Engineering,
University of Toronto.

While the standard slide rule has long been considered as almost synonymous with engineering calculations, there is a rather widespread tendency to belittle its capabilities because of its inherent limitations. Since the slide rule is an analogue device, these limitations are real enough and must be respected, but within its field of application, the slide rule can be a superb instrument and capable of much more than the simple tasks usually given to it.

The present paper explores a number of "other-than-ordinary" applications including use of procedural strategy to increase numerical accuracy, extension of the proportion principle, and solution of polynominal equations of degree five or less.

IN THE CURRENT, and proper, interest among engineers for wider use of electronic computer facilities, it must be realized that many of the "old ideas" are by no means superseded, a point of view which has been previoulsy discussed by the writer[1] As there set forth "The traditional computer of the engineer . . . the standard slide rule . . is ordinarily considered as merely useful for three-figure multiplying and dividing, but properly employed, it can often yield unusual results with great ease and sometimes with accuracy not nearly so readily attainable by other means." As its title suggests, the present paper will endeavour to indicate some "other-than-ordinary" slide rule uses which have been developed by the writer. The "ordinary" uses are certainly worthy of greater amplification than they usually get, but these standard procedures are generally available in makers' manuals and in books.[2, 3, 4, 5, 6]

To set the record straight, the "standard slide rule" here considered is a 10-inch (25-cm.) model carrying



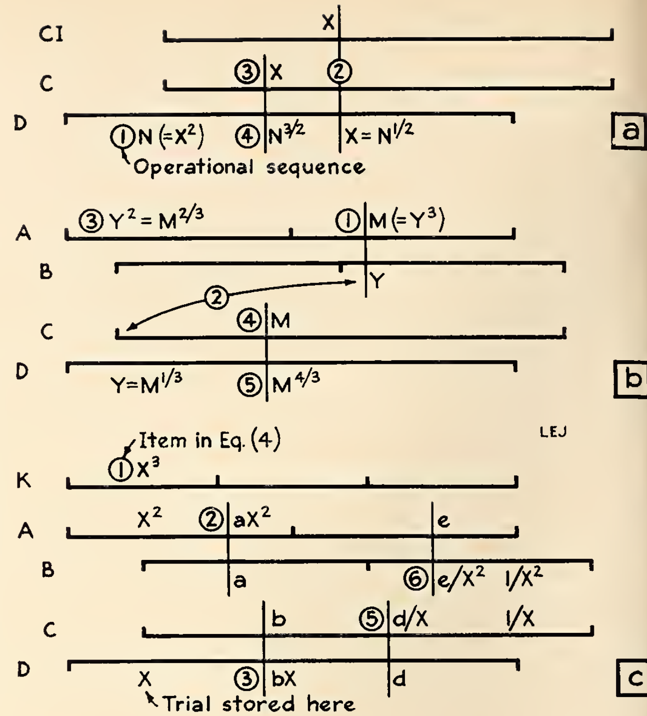


Fig. 1 (a) Schematic arrangement of scales on the "standard slide rule".

(b) The principle of proportion:

$$\frac{Z_1}{Y_1} = \frac{Z_2}{Y_2} = \frac{Z_3}{Y_3} \ldots = \frac{1}{Y'} = X$$

The principle of "inverted" multiplication and division:

$$Y_2 = Y'Z_2, \qquad \frac{Y_2}{Z_2} = Y', \text{ etc.}$$

Fig. 2 (a) Square root, (b) Cube root, by the "homing process";

(c) Solution of fifth degree polynomial equation by "modified homing process".

at least the scales shown in Fig. 1a, which are schematically segregated into the two broad groupings of "body scales" and "slide scales" and labelled with the designations usually encountered. Any given make or model may have other scales as well (including, perhaps, scales of inches and centimeters) and will certainly exploit both sides of the rule, each with its distinctive array of "neighbours". To permit the utilization of its full capabilities, the slide rule must, of course, be accurately assembled and adjusted.

Although usually taken very much for granted, the distinctive attributes of the slide rule are worthy of brief review, since an appreciation of these capabilities can greatly enhance the scope of the instrument. The slide rule is an analogue computer in which numbers are represented by lengths on special scales. The fundamental length unit corresponds to the logarithmic equivalent of a tenfold number ratio, and will be referred to as a "decade". By use of the "lateral transfer" principle (usually via the cursor), these special scales can be taken in appropriate pairs to provide the equivalent of a set of functional tables. The relative movement between slide and body gives the "addition and subtraction" facility and, due to the logarithmic foundation of the scales, this permits the simple operations of multiplication, division, and so forth. It must be realized that the slide rule usually takes care of only the mantissae and so the decimal point location in any problem must be handled "externally". "Running off" the end of the rule can often be avoided by proper use of the folded scales, and in multi-factor operations, non-productive re-settings can be eliminated by judicious alternation of the multiplication and division processes; interchange of multiplications and division as needed can often be accomplished through use of the reciprocal scales.

Any analogue device is limited by the accuracy of the measurements involved, and in the standard 10-inch slide rule, the numbers can be determined to little better than 1/10 of 1%. For many engineering calculations, this matches the accuracy of the data, and by its nature, the slide rule suppresses extraneous figures in the answers. There are other distinctive attributes as well. Any intermediate answers in a problem are very conveniently stored and transferred, either opposite the cursor or a scale index, and there is frequently no need to be concerned with the numerical value of such an intermediate answer as the value can be handled without the operator's needing to know what it is. Further, since the slide rule is a graphical device, it has the important facility of being able to display, not only the answer called for, but other answers as well in the same general vicinity. This means that a problem may be terminated in its early stages

Example 1:

$$0.937 \times 37.08 = (1 - 0.063)37.08 = \begin{array}{r} 37.08 \\ -\ 2.34 \\ \hline 34.74 \end{array}$$

(via slide rule)

(via desk calculator 34.7440)

Example 2:

$$\frac{80.684}{39.826} = \frac{79.652 + 1.032}{39.826} = 2 + \frac{1.032}{39.826} = \begin{array}{r} 2 \\ +0.0259 \\ \hline 2.0259 \end{array}$$

(via slide rule)

(via desk calculator 2.025913)

The strategy suggested is to break the problem into two parts, one of which can be handled easily with the slide rule, and the other disposed of easily without the slide rule. A preliminary exploration, or a final independent check, is always available by doing such problems in the routine way (that is, without benefit of any "strategy"). (Examples 1 and 2).

Occasionally a problem will lend itself to solution by means of a series which converges rapidly.[7] For the binomial theorem, a form very useful for slide rule work is

simply because the graphical nature of the rule permits the operator to perceive when he is sufficiently close to the answer required.

Certain corollary attributes of the slide rule's logarithmic make-up are worthy of mention. The "principle of proportion" is illustrated in Fig. 1b, which serves also to indicate the principle of "inverted" multiplication and division. It will be clear, for either principle, that the essential feature involves the relative movement of two scales, without any fundamental preference as to which is on the slide and which is on the body.

Although the slide rule operations usually ignore the location of the decimal point in factors for multiplication or division, it is sometimes necessary to give partial or full attention to this matter, as in procedures involving square and cube root and the trigonometric functions. It is useful to realize that the square and cube scales can be used together to give two-thirds and three-halves powers, which can each be handled with a single cursor setting if the root operation is performed first.

The following paragraphs will illustrate how the fundamental slide rule features can be utilized in certain special applications. The operations described are primarily concerned with enhanced arithmetic; whether the procedures are justified by the relevant circumstances is, of course, a very important matter, but this is not at present the concern of the writer.

1. Extra Significant Figures by Proper "Strategy".

Not infrequently the nature of a calculation is such that while the ordinary slide rule answer provides a respectable enough three-figure result, we may be anxious to have at least a four-figure answer, because, say, we are desirous of evaluating a difference (a process which often degrades the relative accuracy of the result). For example, 34.7 − 33.9 = 0.8, where the three-figure numbers yield no better than a one-figure difference. If we could have provided values such as 34.74 − 33.87 = 0.87, this result would have produced a potentially much more useful answer.

Example 3:

$\sqrt{64.348}$

For $n = \frac{1}{2}$ and x positive, Eq. (1) becomes

$$(1 + x)^{1/2} = 1 + \frac{x}{2} - \frac{x^2}{8} + \ldots$$

Hence

$$64.348^{1/2} = 64^{1/2}\left(1 + \frac{0.348}{64}\right)^{1/2} = 8(1 + \underset{\text{(via slide rule)}}{0.00544})^{1/2}$$

$$= 8\left[\begin{array}{lr} & 1 \\ \text{(via slide rule)} & +0.00272 \\ \text{,,} & -0.000004 \\ \hline & 1.002716 \end{array}\right]$$

$$= \quad \begin{array}{lr} & 8 \\ \text{(via slide rule)} & 0.0217 \\ \hline & 8.0217 \end{array}$$

(via desk calculator 8.021721)

$$(1 \pm x)^n = 1 \pm nx + \frac{n(n-1)}{2!}x^2 \pm \frac{n(n-1)(n-2)}{3!}x^3 + \ldots \qquad (1)$$

which is valid for any value of n and for x in the range −1 to +1. When x can be made relatively small, only a few terms may be needed (Examples 3 and 4).

At a somewhat lower level of sophistication, it may be desired to extract a rather better square root than is available from the A- and B-scales, or a better cube root than can be obtained from the K-scale (or it may be that one or another of these multi-decade scales is missing from the rule in hand). The desired results can be obtained by what might be termed a "homing process", as indicated in Fig. 2a, b.

In Fig. 2a, for finding $X = N^{1/2}$, the index of the slide is set on N and the cursor is then moved until the same reading (X) is obtained on CI as on D (sequences (1), (2). That is, the cursor is "homed" upon the value of X (by making the CI- and D-scales each read the same under the cursor). As always in square root problems, there are two values to be found for the significant figures of any N, only one value of which, of course, is correct for the problem given; in Fig. 2a, the "other" value would be determined when the right index of the slide is placed opposite N.

In Fig. 2b, for finding $Y = M^{1/3}$, the value of M is located on A with the cursor and the slide is then moved

*By extending the procedures of Fig. 2a, it is possible to obtain fairly easily the three-quarters and five-quarters powers—a facility of considerable convenience in evaluating specific speed for turbomachinery, where such functions of the head are needed. The use of the full-length scales generally permits of enhanced numerical accuracy over other slide rule methods.

Example 4:

1/39.826

For $n = -1$ and x negative, Eq. (1) becomes

$$(1-x)^{-1} = 1 + x + x^2 + x^3 + \ldots$$

Hence

$$\frac{1}{39.826} = \frac{1}{40 - 0.174} = \frac{1}{40}\left(\frac{1}{1-\frac{0.174}{40}}\right)$$

$$= \frac{1}{40}(1 - 0.00435)^{-1}$$

$$= \frac{1}{40}\left[\begin{array}{lr} & 1 \\ & +\,0.00435 \\ \text{(via slide rule)} & +\,0.00002 \\ \hline & 1.00437 \end{array}\right]$$

$$\begin{array}{lr} = & 0.025 \\ \text{(via slide rule)} & 0.0001092 \\ \hline & 0.0251092 \\ \text{(via desk calculator} & 0.02510923) \end{array}$$

Cross check on Example 2:

$$\frac{80.684}{39.826} = 80.684 \times 0.0251092$$

$$= (80 + 0.684)0.0251092 = \begin{array}{lr} & 2.008736 \\ \text{(via slide rule)} & 0\ 01717 \\ \hline & 2.02591 \end{array}$$

until the same value (Y) is read on B under the cursor as on D opposite the slide index (sequences (1), (2)). (Three values of Y in all may be so found.) As one of the author's colleagues pointed out, sequence (3) in Fig. 2b gives $M^{2/3}$, and this idea may be extended to provide $N^{3/2}$ (sequences (3) and (4) of Fig. 2a) and $M^{4/3}$ (sequences (4) and (5) of Fig. 2b).*

2. Extensions of the Principle of Proportion

Since the slide rule scales are assembled in parallel, the lateral transfer principle will operate effectively even though one of the scales does not enter the operator's conscious observations. The proportion principle illustrated in Fig. 1b has therefore quite extensive possibilities—a standard example being the "law of sines":

$$\frac{a}{\sin A} = \frac{b}{\sin B} = \frac{c}{\sin C}$$

which is used in certain of the triangle solutions of plane trigonometry (for a triangle of sides a,b,c and respectively opposite angles A, B, C). On some earlier slide rule models, the sine scale is worked against the A- and B-scales, but this fact changes only the location on the rule where the values are handled.

By extending the general proportion principle to other scales on the rule, it is possible to deal with such ratios as are shown in the following table.

Proportion	Slide Rule Scales
$\frac{X^{1/2}}{Y}$ or $\frac{X}{Y^2}$	A and C (or B and D)
$\frac{X^{1/3}}{Y}$ or $\frac{X}{Y^3}$	K and C
$\frac{X^{2/3}}{Y}$ or $\frac{X}{Y^{3/2}}$ or $\frac{X^{1/3}}{Y^{1/2}}$	K and B
$\frac{X^{1/2}}{1/Y}$ or $\frac{X}{1/Y^2}$; ($X^{1/2}Y$ or XY^2 = constant)	A and CI
$\frac{X^{1/3}}{1/Y}$ or $\frac{X}{1/Y^3}$; ($X^{1/3}Y$ or XY^3 = constant)	K and CI

3. Solution of Polynomial Equations of Degree Five or Less

Not infrequently, it is necessary to solve equations of higher order than quadratic, and while there are standard algebraic and trigonometric solutions and associated theorems,[8] the labour (and mental inertia) involved usually makes these methods unattractive to a busy computer. Furthermore, if the polynomial arises from a standard interpolation formula (such as those of Gregory-Newton, Stirling, Bessel, etc.), not only is the rough magnitude of the answer known (from a graphical sketch, say), but its value may not be required much beyond two or three figures. In such cases, the slide rule provides an answer with any desired degree of refinement (up to its inherent capabilities of accuracy). Even if the slide rule's best is not good enough, the rule does perform a very useful function in exploring the situation prior to more refined numerical procedures.

The method of solution described below involves a "modified homing process" in which each trial can be handled in a single setting of the slide (although an end-to-end shift may be necessary to permit of "reaching" all the factor involved). The method exploits fully the possibilities of the various scales, and it is noteworthy to observe how essentially smooth is the data flow therefrom.

Since the standard slide rule has only one K-scale, the method cannot deal with equations beyond the 5th degree, but in usual engineering computations this will not normally be any hardship; as a further consequence, it is necessary that the coefficient of the highest power term be unity, which, of course, is easily enough accomplished. The method under consideration is therefore concerned with a function of the form

$$F(X) = X^5 + aX^4 + bX^3 + cX^2 + dX + e \qquad (2)$$

where a, b, c, d, e are numerical (real) coefficients, and the necessary procedure is to find a value of X such that $F(X) = 0$. The description given will apply to the 5th degree function shown in Eq. (2); functions of the 4th or 3rd degree will be correspondingly simpler.

Since an n-degree equation has n roots, it is important to have some inkling as to the various solutions that might be produced so as to guard against using a result which is mathematically correct but extraneous to the physical problem in hand. A very useful rule from algebra is "Descartes' Rule of Signs" which states that in a

polynomial such as Eq. (2) with real coefficients and with powers of X arranged in descending order, there can be no more positive real roots than there are variations of sign in $F(X)$, and no more negative real roots than variations of sign in $F(-X)$. In Eq. (2) (assuming all the literal coefficients are positive) there are no changes of sign and therefore there cannot be any positive real roots. By replacing $+X$ with $-X$, there results

$$F(-X) = -X^5 + aX^4 - bX^3 + cX^2 - dX + e \qquad (3)$$

which has five changes of sign. There may, therefore, be five negative real roots but there may also be one or two pairs of conjugate complex roots (with correspondingly fewer real roots).

Assuming that appropriate control is available over the sign and general magnitude of the value of X being sought, we can now proceed to the slide rule method. It is first necessary to divide Eq. (2) through by X^2, yielding

$$f(X) = \overset{(1)}{X^3} + \overset{(2)}{aX^2} + \overset{(3)}{bX} + \overset{(4)}{c} + \overset{(5)}{\frac{d}{X}} + \overset{(6)}{\frac{e}{X^2}} \qquad (4)$$

The superimposed numbers are for identification in Fig. 2c. The trial value for X is stored on the D-scale opposite the index of the C-scale and by successive movements of the cursor, the several products in Eq. (4) can be evaluated. When the sum of the items on the right hand side of Eq. (4) comes sufficiently close to zero, the corresponding value of X represents one of the roots of the equation. The sum need only be as close to zero as the corresponding accuracy required in X, but in any case all that need actually be accomplished is that the sum "straddle" zero; from here the "true" X can be determined by relatively simple interpolation. It will be seen that the suggested procedure takes advantage of the "inverted" multiplication technique considered in Fig. 1b. Before summing the terms, the operator must of course watch that signs and decimal point location are correct, but if his bookkeeping has any orderliness at all, he need do the actual thinking only for the first trial, as the subsequent trials will follow a consistent pattern (Example 5).

Discussion

In an early paragraph of this paper, reference was made to the need for "external" handling of the decimal point—since the logarithms used by the slide rule comprise only the mantissae and essentially ignore the characteristics. Very often the decimal point can be located quite easily by inspection, but, in less obvious cases, some systematic approach must be devised. The factors are usually rounded off drastically to give simple values easy to manipulate, with special attention to the proper powers of 10 in very large or very small factors.

It is always highly desirable to have some independent means of approaching an answer—no matter how rough the method might be—so as to guard against mistakes in the procedure. The necessary "external" operation of locating the decimal point in a slide rule computation provides a remarkable opportunity for checking that computation independently. The writer recommends a technique which may be called "compensatory rounding", in which the simplification of the factors is directed towards keeping the "rough" answer as close as possible to the "refined" answer. If two factors occur as part of a product, then one will be rounded downwards and the other upwards, while if the two factors occur as part of a division, the two are rounded in the same direction, either upwards or downwards, whichever is more convenient. In using this procedure the writer has found, almost without exception, that if the "rough" answer differed from the slide rule result by more than 10% or so, then some sort of mistake was involved, typically the omission or inversion of one of the several items.

Concerning the special slide rule methods that have been discussed in this paper, it may well be found that some of the ideas, and others not mentioned, have been independently developed or at least anticipated by other workers. It is quite natural that this should be so, for all that is required is a good knowledge of slide rule principles, an active imagination and the motivation provided by the demands of practical problems. No all of the techniques mentioned in this paper necessarily have immediate practical applications, but the important fact to be realized is the great versatility of the standard slide rule. When its capabilities are fully realized, it can be a powerful aid in computation. Occasionally it takes the place of a more sophisticated device, such as a desk calculator which is at the moment not at hand, but more often, perhaps, by its very speed, convenience and versatility, the slide rule commands a respected place in its own right.

Example 5

$F(X) = X^5 - 23.4X^4 - 0.749X^3 + 0.0532X^2 + 3.37X + 10.9$
Changes of sign in $F(X)$: 2; % no more than 2 positive real roots
Changes of sign in $F(-X)$: 3; % no more than 3 negative real roots
Divide through by X^2:

$$f(X) = X^3 - 23.4X^2 - 0.749X + 0.0532 + \frac{3.37}{X} + \frac{10.9}{X^2}$$

Set up systematic worksheet, try $X = +1.0$ for simple start and round off items appropriately:

X	+1.0		+0.8		+0.9		+0.878	
	+	−	+	−	+	−	+	−
$+ X^3$	1.00		0.51		0.73		0.68	
$-23.4\ X^2$		23.40		15.00		18.96		18.06
$-0.749X$		0.75		0.60		0.67		0.66
$+0.053Z$	0.05		0.05		0.05		0.05	
$+3.37/X$	3.37		4.22		3.74		3.84	
$10.9/X^2$	10.90		17.05		13.45		14.15	
	15.32	24.15	21.83	15.60	17.97	19.63	18.72	18.72
f (X)	*	−8.83	+6.23	**		−1.66	0.00	√

** By inspection of the various terms, we perceive that $f(X)$ will approach 0 if we diminish X; hence try +0.8.

** Since $f(X)$ has overshot 0, try X closer to +1.0, say +0.9; when new $f(X)$ has been evaluated, plot graph of X vs $f(X)$ for the three sets of values and interpolate for X to give $f(X) = 0$. Then check on this value.

√ For $X = +0.878$, $f(X) = 0$ within the accuracy of the slide rule results; hence $X = +0.878$ gives one of the required roots. (The other real roots can be evaluated by similar procedures.)

References

1. Jones, L. E. **"Computers and the engineering student"**, Canadian Consulting Engineer, Sept. 1959: pp. 52-55.
2. Hills, E. J. **"A Course in the Slide Rule and Logarithms"** (Ginn) 1943.
3. Banhagel, E. W. **"Logarithms and Slide Rule for Practical Use"** (Ziff-Davis) 1945.
4. Johnson, L. H. **"The Slide Rule"** (Van Nostrand) 1949.
5. Thompson, J. E. **"The Standard Manual of the Slide Rule"** (Van Nostrand) 2nd ed., 1952.
6. Arnold, J. N. **"The Slide Rule—Principles and Applications"** (Prentice-Hall) 1954.
7. Eshbach, O. W. (Editor) **"Handbook of Engineering Fundamentals"** (Wiley) 1st ed., 1936: Secs. 2-15; 2-16; 2nd ed., 1952: Secs. 2-7, 2-8.
8. ibid. **1st ed.**: Sec. 2-11; 2nd ed.: Sec. 2-14.

Selection of Dike Freeboard and Spillway Capacity for Grand Rapids Generating Station

I. W. McCaig,
Director

F. H. Jonker,
Hydraulic Engineer

W. Hamilton,
Engineer, H. G. Acres & Company Limited, Consulting Engineers, Niagara Falls, Ont.

THE GRAND RAPIDS Generating Station presently under construction for Manitoba Hydro is located on the Saskatchewan River just upstream from its outlet into Lake Winnipeg. The reservoir is formed by a concrete spillway dam built in the channel of the Saskatchewan River near the head of the Grand Rapids, with adjoining earth dams and a series of dikes across low points in the height of land immediately west of Lake Winnipeg. The reservoir when filled will have a length of 64 miles and, as shown in Fig. 1, will contain the present Cedar Lake and Cross Lake. It will flood an extensive area of marsh land to the north and west of these lakes. Its depth will vary from just a few feet in the marshland area to about 40 ft. in the areas of Cedar and Cross Lakes. The earth dams and dikes required to form the reservoir will have a total length of approximately 15 miles, and heights up to 90 ft.

Selection of freeboard and spillway capacity for this development required a study of meteorological and hydrological data to estimate the wind setup and wave action that could occur within the reservoir and the magnitude of floods entering it.

Preliminary studies showed that wind setup within the reservoir could rise as high as 5 ft. where the dikes are located, and that the height of waves in Cross Lake could exceed 8 ft. Considerable expense would be involved in providing dike freeboard to withstand the maximum setup and wave runup.

The preliminary studies also indicated that an expensive spillway arrangement would be required if no flood storage were utilized and it were assumed that floods entering the reservoir had to be passed immediately through it.

To obtain maximum economy in the Grand Rapids layout, a comprehensive study was made of freeboard requirements including the determination by wave diffraction and refraction analyses the height and period of waves reaching the various earth dikes, and consideration was given to the use of flood flow forecasting and flood storage to reduce spillway discharge requirements. This paper outlines the methods used to determine the effect of windstorms over the reservoir and to control the rise in water level due to floods entering the reservoir. Application of these methods, considering various spillway capacities, and a statistical analysis of water levels in the powerhouse area, led to the selection of an optimum combination for dike freeboard, flood storage and spillway capacity. The capacity of this combination was later checked to ensure that the maximum probable flood derived from meteorological considerations, could be passed safely through the reservoir.

Wind Setup

When a wind blows over a lake or reservoir, the shear stress of the wind on the surface of the lake moves the sufface water towards the lee shore and raises the level at that location. If the wind is of sufficient duration, a stable slope will be established with water moving along the lake surface in the direction of the wind and returning along the bottom.

In a long shallow lake the rise in water level or setup on the lee shore may be large, as the return flow along the bottom is restrained by frictional forces. Observations in Lake Erie dur-

ing the fall of 1956 showed the water level on the lee shore at Buffalo to rise eight feet above normal lake level. The length and average depth of Lake Erie are 130 miles and 60 ft. respectively. Significant setup has also occurred in Lake Winnipeg. The length, depth and orientation of the Grand Rapids reservoir indicate that a strong north or northwest wind could be expected to blow out large quantities of water from the shallow areas at its west end into Cedar Lake and towards the Grand Rapids site.

Many formulae are available for calculating the magnitude of setup. These formulae have been developed from observations in large lakes and experimental investigations in hydraulic laboratories. All the formulae are of the same general form, but vary slightly in detail. For the case of fairly deep water, the formulae take the form:

$$h = CK\frac{W^2L}{2gD}$$

where

h = wind setup above still water surface

W = wind velocity

g = acceleration due to gravity

L = length of reservoir being considered

C = a constant, depending largely on bottom roughness

K = a factor, depending on the plan shape of the reservoir

The general form of equation (1) shows that the setup is proportional to the square of the wind velocity over the reservoir and, therefore, increases rapidly with this velocity. It was, therefore important in the study of freeboard requirements to determine as accurately as possible the wind speeds which can be expected over the reservoir. The three nearest stations at which wind speeds have been measured for a considerable time are located at the Pas, Island Falls and Winnipeg. A statistical analysis of records at these stations showed the frequency with which extreme wind storms could be expected. However, these weather stations are located on land, and investigations by Major Hunt of the United States Corps of Engineers have shown that wind speeds measured over the water in Lake Erie are considerably higher than those measured at adjacent land stations. The variation is particularly evident during the fall when the water temperature exceeds the temperature of the air. At that time, convection currents over the lake increase the wind speeds during moderate storms to some 20 to 80% in excess of speeds measured at land stations.

In the analysis of setup in the Grand Rapids reservoir, the ratio of overwater to overland speeds was taken to be 1.5 for overland wind velocities up to 50 m.p.h., but above this velocity the ratio was decreased progressively to 1.3 for an overland wind speed of 70 m.p.h. The decrease in the ratio with increasing wind velocity can be deduced from meteorological theory and is, in general, confirmed by measurements made in Lake Erie.

From a detailed analysis of the available information, a value of $C = 3.84 \times 10^6$ in formula (1) was selected and used for setup calculation in the Grand Rapids reservoir. The factor K has been derived theoretically for various plan forms. For wind blowing towards the apex of a triangular plan form, the constant $K = 1.33$, and for a wind blowing in the opposite direction it is 0.67. Intermediate shapes have a value of K lying between these extremes. For a rectangular reservoir $K = 1$. Along the windward shore of a reservoir where

Fig. 1. Plan of reservoir showing location of dikes.

there are extensive areas in which the water is very shallow, these areas may be blown dry during high winds. The water surface in other shallow areas is parabolic rather than straight, and in these areas Formula 1 has to be modified to take into account this fact. As the Grand Rapids reservoir has within it considerable variations in shape and depth, each area of approximately constant depth had to be treated separately and total setup calculated by a step-by-step method.

The calculation was further complicated by the fact that the reservoir consists of two separate sections which are connected by a rather narrow channel located at Flying Post Rapids. While these rapids will be submerged when the Grand Rapids reservoir is formed, the topography will form a constriction between the two sections of the reservoir. To determine the maximum setup at the powerhouse, two separate wind setup calculations were made for the two areas and the head difference across Flying Post Rapids was determined for each time interval. This difference determined the volume of water which

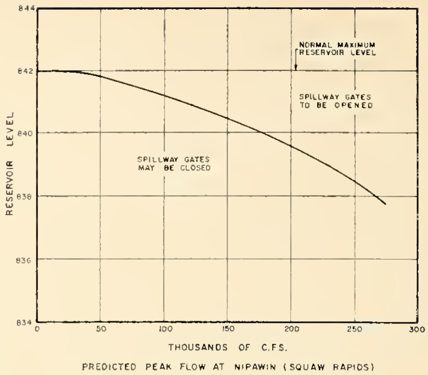


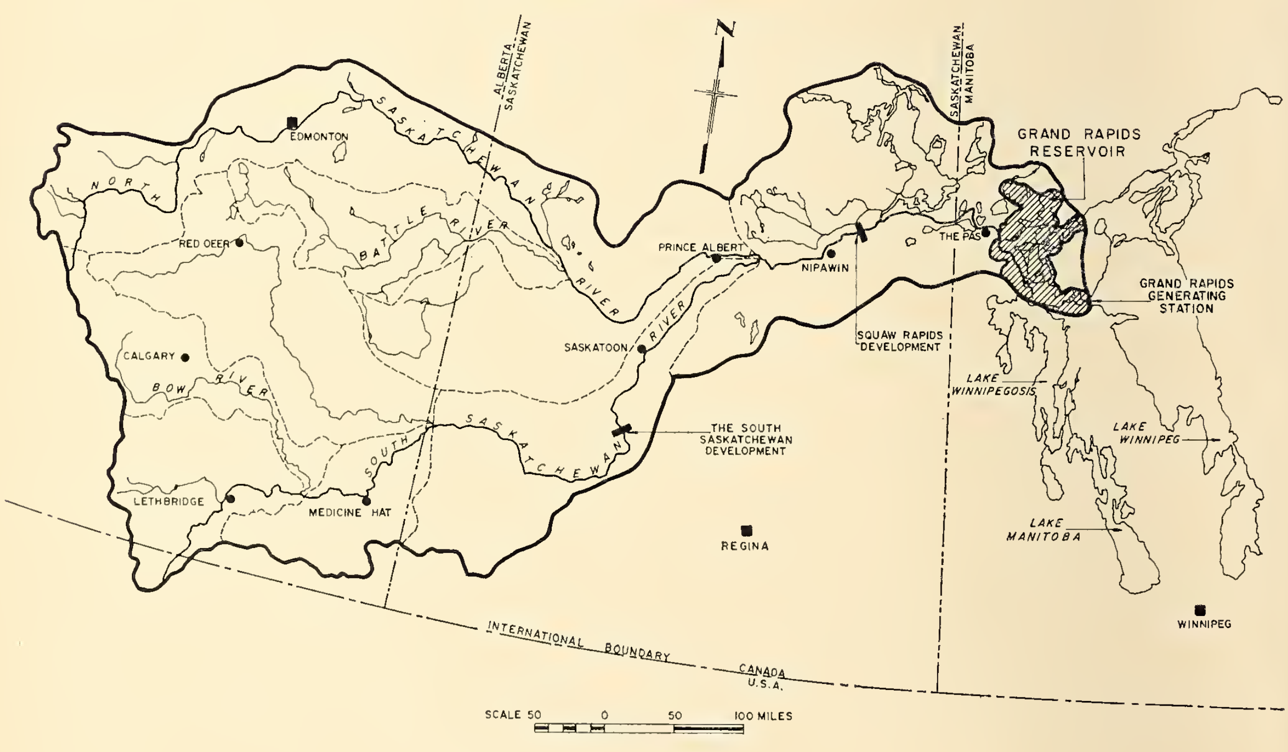
Fig. 3. Spillway rule curve.

flowed from Cedar Lake into Cross Lake and thus the average water level in Cross Lake for the succeeding period. The maximum wind setup at the powerhouse depended not only on the wind velocity but also on the duration of the wind storm, since the duration and head differential across Flying Post Rapids determined the volume of water available to raise the level in Cross Lake. Calculations showed that due to the constriction at Flying Post Rapids a 12-hour wind storm would not produce as high a setup as a storm of like probability but lower average speed over 24 hours. For storms of 36-hour and 48-hour duration, the setup was approximately equal to that with the same probability calculated on a 24-hour basis.

It may be interesting to note that a flow of approximately 400,000 c.f.s. must be established through Flying Post Rapids for the setup to reach its maximum value in 24 hours.

The analysis of wind velocities and calculation of setup indicated that the average maximum yearly windstorm would produce a setup of approximately 2½ ft. in the powerhouse area. A windstorm having an estimated return period of 5,000 years would cause a setup of 5 ft. All calculations of setup were based on the assumption that the wind direction during the critical storm is constantly in the direction of a line through Flying Post Rapids and the powerhouse. In fact the wind direction will change considerably during the course of a storm, and the assumption therefore gives conservative values of setup.

Fig. 2. Map of drainage basin.



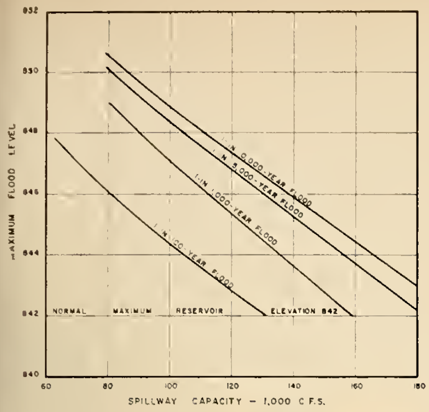


Fig. 4. Maximum reservoir levels during floods.

Flood Flows

The Saskatchewan River flows in a generally eastward direction from its headwaters in the Rocky Mountains, through the Prairie Provinces to its outlet in Lake Winnipeg. The drainage basin, shown in Fig. 2, has an area of some 156,600 square miles. The river generally experiences two flood peaks each year. The first peak usually occurs in April or May and is caused by snowmelt in the prairies and foothills. The second peak occurs during the summer months and is caused by precipitation in the headwaters and snowmelt on the higher peaks of the Rocky Mountains.

When the snowmelt occurs later than usual and when the heavy rains start rather early in the season, the spring and summer floods at The Pas combine into one long period of high water and cannot easily be distinguished. In studying the flood discharges, no distinction was made between spring floods and summer floods, the entire flood period being considered as a whole.

The basic characteristics of the floods which can be expected to occur in the future at Grand Rapids were determined from a statistical examination of the peak flows and volumes of recorded floods at Prince Albert and Saskatoon, and from a review of design floods used for the South Saskatchewan River Project. From these data a series of design floods with return periods from 100 to 10,000 years were established. These are listed in the following table:

Estimated Return Period (Years)	*Peak Inflow (c.f.s.)*	*Flood Volume (b.c.f.)*
100	215,000	1,280
1,000	285,000	1,520
5,000	350,000	1,700
10,000	362,000	1,750

Flood inflows were routed through the Grand Rapids reservoir assuming that, during a flood period, the reservoir would be operated in accordance with the following:

(a) The flood flow at Squaw Rapids could be predicted seven days in advance.

(b) The reservoir would be drawn down so that on the basis of daily flood predictions it would just be possible to refill the reservoir after the peak of the flood had passed.

The rule curve that will be used for this method of operation is shown in Fig. 3. This curve indicates that if the flood has a predicted peak flow of 250,000 c.f.s., the reservoir should be drawn down to elevation 838.5 ft. After the peak discharge has passed, as indicated by a predicted reduction of inflow, the spillway gates would then be closed and the reservoir would, on the basis of past experience, be refilled at the end of the flood.

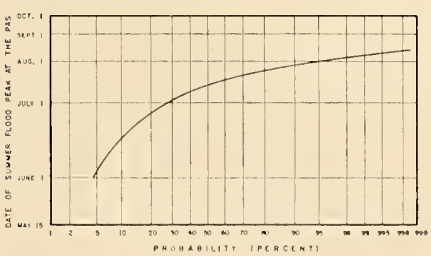
The maximum reservoir levels resulting from the above tabulated inflows were calculated for a number of spillway capacities between 80,000 and 180,000 c.f.s. In this computation it was assumed that the average powerhouse discharge would not be less than 10,000 c.f.s. and flood storage was discounted in Moose Lake where the inflow and outflow are restricted by narrow channels. The maximum reservoir levels obtained in this way are shown in Fig. 4.

Seasonal Distribution of Floods and Wind Setup

As was mentioned in the previous paragraph, the majority of floods occur in the spring and summer. The seasonal distribution of the peaks of recorded floods are shown in Fig. 5.

This figure shows that 95% of the flood peaks passed The Pas before the beginning of August, and approximately 60% before July 15. Computations have shown that the maximum water level in the Grand Rapids reservoir is reached approximately 15 days after a flood peak passes The Pas; thus 60% of the maximum flood levels in Cedar Lake would occur before August 1, and only 5% after August 15.

Fig. 5. Seasonal distribution of recorded floods.



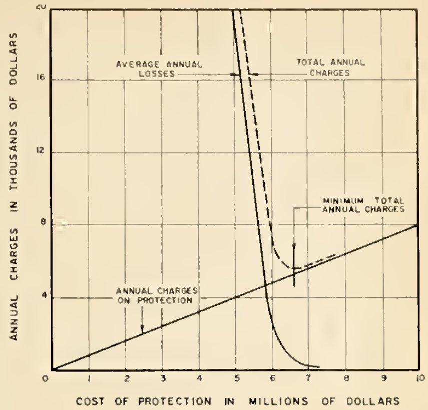


Fig. 6. Economy of protection.

In previous reference to wind speeds, it was noted that wind velocities over water are substantially higher than the wind velocities over land when the temperature of the water is higher than the temperature of the air. This condition occurs generally in the fall of the year before the lakes are frozen over. In the absence of local data on which the temperature of the Grand Rapids reservoir could be forecast, a review was made of watei temperature measurements taken at Kelsey on the Nelson River. These temperatures indicate that, assuming the Grand Rapids reservoir to be subject to climatic effects similar to the northern part of Lake Winnipeg and the Nelson River, the water temperature in the Grand Rapids reservoir will exceed air temperatures by a substantial amount only after the beginning of August. Since records showed the overland wind speeds after August to be at least equal to the average yearly wind speeds, it can be concluded that in the Grand Rapids reservoir the maximum values of wind setup may be expected to occur after August 1. Fig. 5 indicates that 60% of the peak inflows in the Grand Rapids reservoir have occurred before this time, and it is therefore physically not correct to combine maximum flood levels with maximum rise in level due to wind setup.

The extreme length of the Saskatchewan River is another factor affecting the possible coincidence of major floods and extreme setup conditions. The period between the occurrence of a major rainstorm over the catchment above The Forks and the arrival of the resultant flood at The Pas is approximately one month. In that period the meteorological disturbance producing the storm will probably have disappeared and associated high winds will, therefore, not occur at the time of maximum flood levels in the Grand Rapids reservoir.

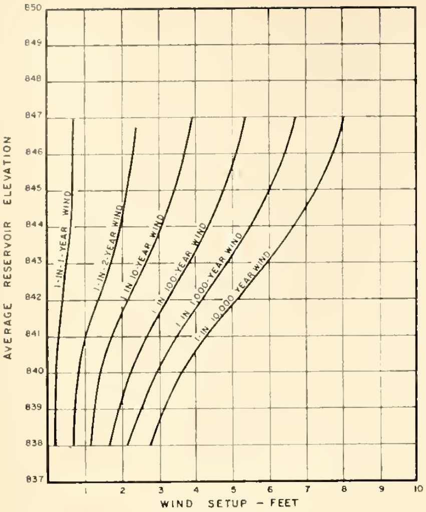


Fig. 7. Wind setup in reservoir.

Summarizing, the study of seasonal distribution of floods and windstorms indicated that it is unlikely that the greatest wind setup in the reservoir will occur during the flood season. It was also established that the meteorological disturbance leading to a flood is likely to have passed before the flood reaches the reservoir. The rise in water level due to floods can, therefore, be considered as statistically independent of the wind setup, in which case the probability of a certain flood and a certain wind occurring together is the multiple of their separate probabilities. For example, for a combined return period of 1,000 years, possible combinations of the return periods of setups and floods would be as follows:

Phenomenon	*Return Period (Years)*				
Flood.......	1,000	500	100	10	1
Wind.......	1	2	10	100	1,000

Economic Design for Setup and Floods

Having established that it is reasonable to design spillway capacity and freeboard on the basis that there is no statistical correlation between the incidence of maximum flood levels and maximum setup, it is pertinent to examine the minimum amount of spillway capacity and freeboard which it is economic to allow for protection against these contingencies.

The quantities which must be evaluated for an economic analysis are:

(a) The average annual cost of providing spillway capacity and freeboard.

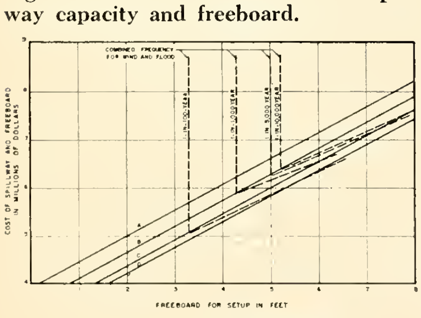
(b) The average annual loss incurred by providing insufficient spillway capacity or freeboard.

The sum of these two quantities represents the total annual charges that can be debited for protection against and for repair of damage due to the action of floods and storms. If the total annual charge is plotted against the cost of providing spillway capacity and freeboard, the total annual charge will pass through a minimum as shown in Fig. 6. If more protection is provided than the value at which this minimum occurs, the additional measures will, in theory, be uneconomic. If less is provided, it is probable that the average annual cost for repair to damages due to floods and winds will be more than the savings in annual charges obtained through reduction of spillway capacity and freeboard.

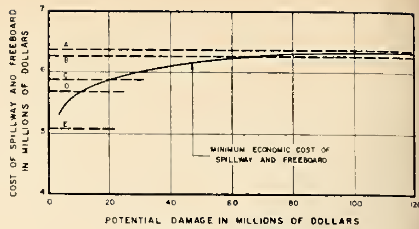
To find the minimum average annual cost of providing protection against floods and setup of a certain combined frequency, it is necessary to find the most economic combination of spillway capacity and freeboard. This was done as follows: Firstly, the maximum flood level in Cross Lake was calculated for floods of various frequencies and for various spillway capacities as shown in Fig. 4. The maximum water levels in the intake area due to wind setup were then calculated for overwater winds in the fall having various frequencies. These maximum water levels are plotted against reservoir flood levels in Fig. 7. It can be seen from Fig. 7 that an increase in flood level also causes an increase in setup. This increase is due to the greater volume of water blown from shallow areas at the westerly end of the reservoir and moved by the wind towards Cross Lake.

With the maximum flood levels and the maximum surges due to wind setup determined, it was possible to examine various combinations of spillway capacity and freeboard required to give protection against the combined action of wind and flood. The total cost of these combinations was plotted in Fig. 8 against required freeboard. Fig. 8 clearly shows for any particular frequency of occurrence, the most economic combination of spillway capacity and freeboard on the dikes.

Fig. 8. Economic combination of spillway capacity and freeboard.



LINE	SPILLWAY CAPACITY	
	GATES	C.F.S.
A	5	175,000
B	4	140,000
C	3	105,000
D	2	70,000



LINE	COMBINED RETURN PERIODS IN YEARS	SPILLWAY CAPACITY		FREEBOARD IN FEET
		GATES	C.F.S.	
A	10,000	4	140,000	5.2
B	5,000	4	140,000	5.0
C	1,000	4	140,000	4.3
D	500	4	140,000	3.9
E	100	3	105,000	3.3

NORMAL RESERVOIR LEVEL 842

Fig. 9. Cost of minimum economic protection related to potential damage.

H. A. Foster, in his paper to The American Society of Civil Engineers on Technical Problems of Flood Insurance, defines the average annual loss due to floods or insufficient freeboard as the total loss over a period of years divided by the number of years. If records were available, the average annual loss could be evaluated as a sum of major and minor losses in this manner. However, for the Grand Rapids Generating Station, such records cannot be produced, so the average annual loss can only be approximated as the total loss due to dikes overtopping, divided by the return period of a combination of flood and setup conditions which would cause overtopping of the dikes. In the calculation of minimum spillway and freeboard requirements, the average annual losses were evaluated for various values of total loss and various frequencies to cover a complete range of the variables under consideration.

Combination of the average annual loss with the minimum cost of flood and setup protection from Fig. 8 gives sufficient information to plot for any assumed value of total damages a curve of total annual charges in the manner indicated in Fig. 6 and thus obtain the minimum spillway capacity and dike freeboard required to protect against specific damages. This was done for a range of values of total damages and the results are presented in Fig. 9. Annual charges on the spillway capacity and dike freeboard were taken as 8%.

The curve in Fig. 9 first rises steeply and then levels off in the area where the value of potential damages exceeds $60 million. The horizontal line B on the plate indicates that if potential damages due to the dikes overtopping were greater than $60 million to $70 million, it would be advisable, even on economic grounds, to provide four spillway gates to discharge 140,000 c.f.s. at the controlled water level, plus 5 ft. of freeboard. These provisions would

give protection against floods and wind action having an estimated return period of approximately 5,000 years. The provision of additional freeboard to horizontal line A, could not be justified on purely economic grounds, unless the potential damage due to the dikes overtopping far exceeds the estimated total cost of the development.

The evaluation of flood damages at a hydro-electric development is complex. It has to include not only the cost of repairing the damage, but also the cost of water lost from the reservoir and of providing alternative services during the period when the development is being brought back into service. If the damage due to the dikes overtopping were not localized, it is conceivable that the total of flood damage due to the above causes could amount to at least $60 million. It was, therefore, recommended that the spillway capacity should not be less than 140,000 c.f.s., and that the dikes should be designed for a setup of 5 ft. Model tests have shown that, at the controlled water level, 140,000 c.f.s. can safely be discharged through four 40 ft. wide spillway gates.

Determination of Freeboard on Individual Dikes

The freeboard required to ensure a stable dike section and to prevent overtopping depends not only on the setup and the flood storage, but also on the action of the waves generated in the reservoir. For the dikes located at the entrance to the forebay, the worst condition occurs with a west or northwest wind. Although the fetch length in that direction is limited to six miles, since the restriction at the Flying Post Rapids effectively prevents waves generated in the Cedar Lake area from entering Cross Lake, waves of up to 8 ft. could be generated in the reservoir during the design storm. When waves generated in the Cross Lake area reach the opposite shore, the waves are diffracted and refracted around the islands located at the entrance to the forebay. This action is shown diagrammatically in Fig. 10. Of the waves generated in Cross Lake, only those waves contained between a-a in Fig. 10 are able to penetrate into the forebay area. The remainder of the waves are diffracted toward the shores. When the waves pass the islands at the entrance, the wave crests fan out and, in doing so, the wave energy is spread out over a longer wave front and the waves diminish in height. However, the same wind also generates waves in the forebay area, and although the fetch length in the forebay area is relatively small, the waves generated within it are, on reaching the dikes, in many instances larger than the remnants of waves which originate in Cross Lake and penetrate between the islands. In determining the maximum wave heights which can occur at the various dikes, both conditions were investigated and the largest waves were used for design purposes.

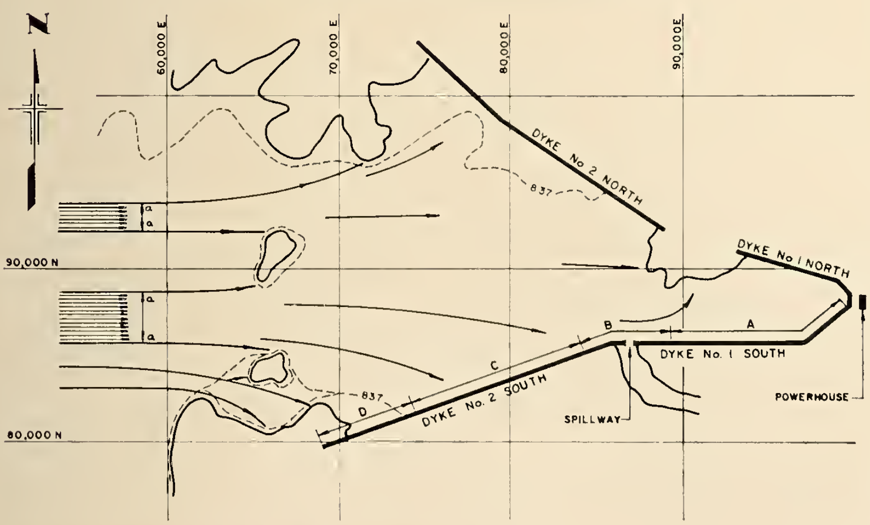
Waves which approach the dikes will break either in front of the dike or on the dike slope. In either case, a considerable runup against the dike slope results. Extensive investigations by Hudson and others indicate that the runup above still water level for a rubble-mound breakwater with a slope of 1:2.5 is approximately equal to the wave height. The large size riprap required to withstand the wave action results in a surface of roughness comparable to that used by Hudson; wave runup is, therefore, expected to equal wave height.

The uncertainty in the determination of the wave runup lies in the value of the wave height which should be used in the evaluation. In the calculation of the wave height from diagrams, the height which is obtained is called the "significant wave height"; this is a statistical term which is used to describe the average of the height of the highest one-third of the waves in a group. The maximum wave in a wave group may be as much as 60% higher than the significant wave height. It would be uneconomic to design the dikes to withstand this one maximum wave which, by itself, can do little damage to the dike. Therefore, to obtain criteria for freeboard, a statistical analysis was made of the waves that would have occurred at the various dike sections during a period of 15 years. Examples of the results of this analysis are shown in Fig. 11. The figure shows the number of waves exceeding an indicated wave height during an average open-water season at three locations differing in exposure.

Freeboard requirements for wave runup were based on this frequency analysis. The analysis showed that if freeboard was provided to prevent overtopping by 95% of the waves during the one in 5000-year design storm, only a very small number of waves in the 15-year period examined would have overtopped the dikes. A wave height corresponding to 95% of the waves of the design storm was adopted as a design wave for runup.

Reasonable criteria for use in determining the total freeboard to be allowed on the dikes were, therefore, established to be the worst combinations of flood rise, setup and runup from the design waves, during a storm in which the combination of phenomena have a return period of not less than 5,000 years. The combinations examined ranged from the one in 5000-year flood, and the average

Fig. 10. Refraction of waves in the forebay.



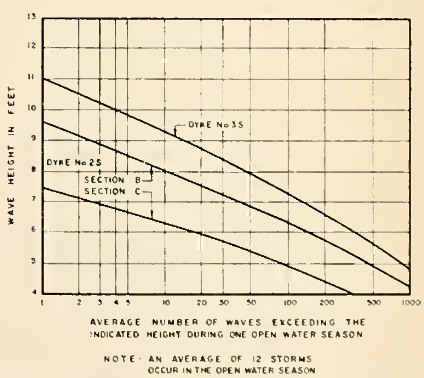


Fig. 11. Statistical analysis of wave heights.

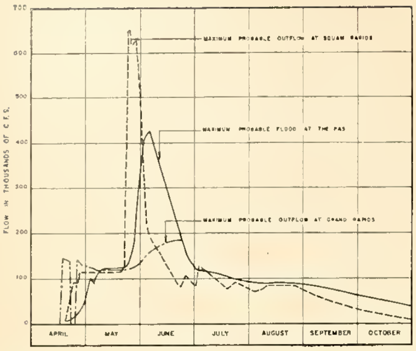


Fig. 12. Hydrograph of maximum probable flood.

yearly windstorm, to the one in 5000-year windstorm on a full reservoir. The computed values for the most extreme combination are as listed in the table at foot of this page.

Figures given in this table were adopted as minimum crest elevations after settlement, except for dikes adjoining the powerhouse intake. As excess spray from runup on these dikes could be inconvenient due to the proximity of the switching station and other structures, the minimum crest elevation of these dikes was increased to elevation 852. This crest elevation provided for all dikes a minimum freeboard of 10 ft. above the controlled water elevation of 842.

Maximum Probable Flood

It is not possible, from a statistical study of the 46 years of flow records in the Saskatchewan River, to determine with complete confidence the average return period of a particular flood inflow. It is necessary, therefore, to examine the physical phenomena which produce floods and to evaluate the combination of conditions required to produce an extreme.

In the design of the South Saskatchewan Dam, the spillway capacity was fixed by the requirement that it should be able to pass the statistically determined design flood without encroaching on the freeboard allowed for waves and setup. However, the spillway capacity was also checked to see that it was adequate to pass the maximum probable flood, defined as that produced by the worst probable combination of meteorological conditions over the catchment. The hydrological work done by the Prairie Farm Rehabilitation Administration as part of the design of the South Saskatchewan Dam and given in its paper to the EIC "Hydraulic Investigations for the South Saskatchewan River Project", has made it possible to make an approximate check that the maximum probable flood could be passed without damage at Grand Rapids. This approximate check was made by assuming that the three following events occurred nearly simultaneously:

(a) The maximum probable outflow from the South Saskatchewan Dam;

(b) The maximum probable flood in the North Saskatchewan River;

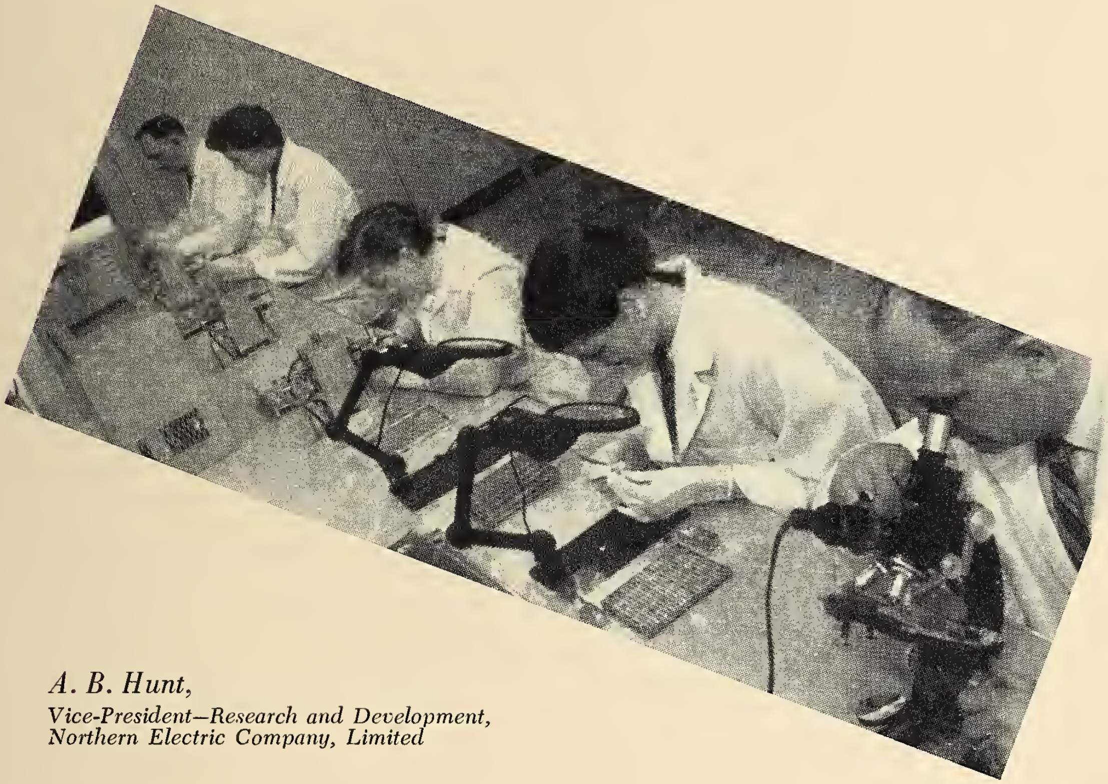
(c) The highest recorded level of base flow due to snowmelt in the upper reaches of the North Saskatchewan River.

The maximum probable outflow from the South Saskatchewan Dam was for this purpose taken as that given in the EIC paper referred to above, and the maximum probable flood in the North Saskatchewan River deduced by adjusting the reservoir inflows given in that paper for the difference in drainage area. The high base flow in the North Saskatchewan River was taken to be 50,000 c.f.s.

The resultant flood hydrograph shown in Fig. 12, when routed through the Grand Rapids reservoir, assuming the prescribed method of operation and the recommended spillway capacity of 140,000 c.f.s., resulted in a maximum flood level of 848.1. This level, which is nearly 4 ft. below the minimum dike elevation expected after settlement, indicated that the spillway and freeboard provisions at Grand Rapids are adequate for this extreme condition. EIC

Dike	*Wind Setup (Ft.)*	*Runup Exceeded by only 5% of the Waves*	*Total (Ft.)*	*Minimum Crest Elevation (Ft.)*
1N	5.0	4.2	9.2	851.2
2N	5.0	5.3	10.3	852.3
1S—Section A	5.0	4.2	9.2	851.2
1S and 2S—Section B	5.0	6.0	11.0	853.0
2S—Section C	5.0	6.7	11.7	853.7
2S—Section D	5.0	5.1	10.1	852.1
3S	5.0	6.7	11.7	853.7
4S	5.0	5.8	10.8	852.8

RESEARCH AND DEVELOPMENT OBJECTIVES



A. B. Hunt,
Vice-President—Research and Development,
Northern Electric Company, Limited

THE RAPID EXPANSION of technology during recent years has placed increasing emphasis on the necessity for greater activity by industry in the field of research and development to support its continued growth in the face of ever-increasing competition. Today, more and more businesses are spending more and more money to increase their competence in this field, for their own survival, not merely for the sake of doing research for government or others. Expenditures alone, however, do not guarantee profitability. Success in the scienitfic fields cannot be assured, but a high degree of effectiveness can be expected with competent staff and administration capable of establishing and maintaining objectives within fields of interest to the Company concerned. It is planned to review this function of research management to show that the changing times have placed new responsibilities on corporate management to ensure the success and profitability of research and development programmes.

Historical Growth of Industrial Research

Seventy-five years ago when the Engineering Institute of Canada was born, research, and even product development, was the result of individual effort seeking new knowledge. Alexander Graham Bell, with meager

laboratory facilities and a few pieces of iron, some wire, and other miscellaneous parts, discovered the fundamental facts of voice communication over wire lines, and also developed the first telephone instrument which transmitted the historic words—"Mr. Watson, come here I want you". Other successful inventions, such as telegraph, wireless, electric incandescent lamps, the generation and distribution of electric energy, sprung from the discoveries of such men as Morse, Marconi, and Edison. Through the individual effort of these scientists, their inventions were reduced to something approaching commercial practice by imagination and dogged determination. Industry had little more to do than make the most of these discoveries and inventions. The next obvious step was for industry to make these discoveries itself. This led to organized industrial research and development. The pattern began to take shape on this continent when the Engineering Institute of Canada was blossoming into its early teens at the turn of the century. The two leading organizations in this field were the General Electric under Dr. Whitney, and the Bell System under Dr. Jewett. From this beginning, industrial research grew at a relatively slow but consistent rate until the last world war. Since that time, it has pyramided and has now reached the proportions of a scientific revolution. Total scientific expenditures in the United States increased fivefold[1] in the last decade. It is estimated that their industrial research for the current year will be about $12 billion out of a total in excess of $15 billion.

Although industrial research in Canada got off to a very slow start, and the level relative to our G.N.P. is below that of other leading industrial countries, it is encouraging to note that the Canadian rate of growth has improved considerably during the last few years. Dr. E. W. R. Steacie, President of the National Research Council, in a recent address at the opening of a laboratory addition of Imperial Oil in Sarnia, reported that during the period 1956-58 research and development performed by industry, including both government and company-financed, expanded at a rate of 10% per year, which is comparable to the growth rates in the United States. That portion financed by industry had an annual growth rate of 20% compared with the U.S. rate of 5 to 6%. There was a reduction of expenditures by both government and industry during 1959 due to cutback of the Armed Services' requirements. Following this abnormal decrease, it is estimated that the trend is continuing upwards although actual statistics are not yet available.

Control and Direction of R and D

This evolution of industrial research and development from the efforts of individuals to corporations on a modest scale, and now expanding into big business itself within the corporations, points to the need for organized control and direction of these activities by senior management. Let us look at the current situation to determine why senior management is concerned about the direction and administration of this research and development activity. Statistics[2] show that in 1958 the United States manufacturing companies performing research and development, spent an average of 3.8% of their net sales on research and development. In the aircraft industry it totalled 17.7%, and for electrical equipment and communications 10.5%. Senior management would not allow advertising, customer engineering, or any other individual expense to reach these proportions without being seriously concerned about how and why the money is spent. The same must apply to research and development.

In our free enterprise system industrial corporations only exist because someone has put up money for them, management gives direction to them, and employees devote their skills and capabilities to them. Any job, whether engineering, production, or research, only lasts as long as the product it helps to turn out is an attractive buy and can be sold at a profit. No profit, no job. No apology is necessary for including research along with the other manufacturing functions. It is not expected that research will produce an immediate return, but in the long run it must be profitable to the enterprise. Research, to be profitable, must be objective within the fields of interest to the company.

Statistics[3] for the year 1959 show that 76% of all research and development in the United States was performed by industry, although largely financed by government. In Britain, it amounted to 58%, and in Canada 36%. The average for the three countries amounted to 73%. In dollars it was 10.3 billion expended by industry out of total expenditures of $14 billion. It is conservatively estimated that for the current year expenditures will be at least 25% higher, with little change in the distribution of effort between industry and other. Industry is therefore responsible for the major effort in research and development, which must, in the long run, be profitable.

We hear a great deal about "blue sky" research. Give a scientist enough freedom and he will come up with something novel and different. This is predominantly the philosophy of government and institutional research. It is probably the correct attitude as this effort is usually financed by public funds and the benefits may accrue to every man, woman and child in the country. It is not for the financial return to a limited number of shareholders. As pointed out earlier, however, this only represents about one-quarter of the total effort in the research and development field. The research work carried out by industry in an ever-expanding field so essential to the economic growth of our country, must be directed and controlled. In the communication industry a novel idea for a new detergent can hardly return a profit to its shareholders. It should not be inferred, however, that scientists in the communication industry lack freedom. Scientific work in this industry covers literally dozens of disciplines ranging from satellite communications to underground cables. The scope is practically unlimited, but if a scientist is interested in soap, he should do his washing in another industry; someone else can make more profitable use of his talents.

Research and development must be challenging to the engineers and scientists concerned. What satisfaction then could anyone engaged in this work obtain from "blue sky" research in a field foreign to the company's interests? He can be sure before he starts that it will not be aggressively promoted by the rest of the organization even if his hard work does produce something novel and different.

Freedom Within Authorized Limits

In spite of the fact that industrial research and development needs to be planned and directed, it must have technical and financial freedom within authorized limits well defined by company policy. Unplanned research and development usually evolves as a result of crash requirements to meet immediate or short-term completion, or engineers are directed to this work when production programmes lag. If the lag is long the work is stopped for financial reasons. Under these circumstances, the work is usually under the direction of the engineering or manufacturing organization and thus dominated by day-to-day requirements.

To obtain freedom, the direction of research and development must be recognized as a senior manufacturing

function and, preferably, physically separated from the other manufacturing activities. It must have a long-term plan with assurance of continuing financial support, as its effectiveness can only be judged over a reasonable period of time, and the effort cannot be turned off and on like a tap as company profits rise and fall. It must support the other managerial functions of the enterprise but cannot be dominated by any one of them.

Scientific Managers

To administer this freedom within the over-all company objective, it requires a new type of scientific manager. A scientist in charge of research does not make him a research manager. Many scientists should remain as scientists and most research organizations recognize this fact today. Equal opportunities for advancement are offered for both managers and those trained in technical skills. The research manager must be skilled in both. The effective research manager is fully aware of over-all company objectives and is keenly interested in the company's profit position. He works in unison with other top management executives and is well informed of their problems and objectives. He is also able to convey to the rest of the management team the objectives of research, what research projects are being carried out and why. The successful research manager has also developed a new and almost unheard-of appreciation of schedules and timing. In the development stage the project must be programmed to tie in with engineering, production schedules, sales promotion, and marketing. If it is going to be too late, the research manager is quite aware of the fact that it will be labelled as unsuccessful and therefore work should be stopped at an early stage.

Setting Objectives

Having established the necessity for broad company objectives of research and development, the climate for the maintenance of a creative organization, and the administrative functions to meet these objectives, it is now appropriate to consider how individual project objectives can be established and maintained within the framework of the over-all company policy. This function is most effectively carried out by a Project Development Planning group, which bridges the gap between research, on the one hand, and product development on the other. It must also coordinate the requirements of manufacturing and marketing. To be specific, any new product concept promoted by research, development, engineering, manufacturing, or sales, must be thoroughly analyzed by the Planning group to determine if it will meet customer requirements as to value, reliability, maintenance and compatibility with existing equipment, to mention a few. It must also determine if manufacturing can produce it at a cost that will return a satisfactory profit, and probably most important, is it novel and ahead of competition?

This analytical work by the Planning organization is carried out before active product development work is authorized, and the feedback from these studies may radically change the concept of product parameters and objectives. This feedback is extremely healthy and prevents many development projects from getting off to a wrong start and unnecessary changes during actual development and field trials. If forecast costs are too high, it presents an immediate challenge to the designers and usually something can be done about this in the early stages. If it lacks novelty or product improvement, applied research, or even basic research, must be called in to provide greater innovation. These are just a few of the many factors which must be co-ordinated and appraised by the Planning organization.

To obtain these objectives the Planning organization must obtain the co-operation and support of all other management functions concerned. It is the key to the establishment of an effective program. The Chief Engineer, the Production Executive, and the Marketing Executive, must know what is going on in the ivory research tower. Research management must know what the other segments of the Company require and keep them informed of progress when ideas start to reach the applied and practical development stage. The time interval has shortened, the research scientist can no longer dream up ideas and then provide them to product development, production, and marketing, when the customer clamours for something new and different. We must be ahead of competition, therefore production must prepare for manufacture as soon as the idea has been proven practical, and marketing must lay its plans long before new products appear on the shelf. It is a co-operative team effort. Whether the focal point of co-ordination is with marketing or product development, it is immaterial and there are management advocates for both. The important thing is that co-ordination and control must be at the senior management level and adequate communications must be maintained between all management groups.

This does not mean that all parts of the organization run research and development, nor is it a committee function. New technology must be provided through fundamental research and more will be said about this later. Before active product development is authorized, research and development must know that marketing is interested in the ultimate product and that manufacturing can produce it by current or easily acquired skills. Preferably, a complete study should be carried out to determine manufacturing cost and marketing potential.

It is recognized that only a small percentage of development projects achieve outstanding success. Planning in itself does not assure success, but it materially enhances the possibility of providing a new product which will meet the customer requirements and will be profitable to the Company concerned. Exploratory research, economic studies, and market analysis, which are the primary functions of Planning, represent only a small proportion of the total cost of any project. Costs mount rapidly as actual development progresses. They reach a peak when the pilot plant and new production facilities must be provided. Failure at this latter stage therefore becomes very costly. To reduce the possibility of failure, objectives, both economical and operational, must be established well in advance. The objectives set for actual product development must be within the technical limitations of the art, but, at the same time, high enough to be challenging and ahead of current competition. They must also be subject to periodic review and adjustment during the development stage, as technology is moving at a rapid pace.

Fundamental Research

Fundamental and applied research are the main sources of innovation. A new product without improvement or novelty over existing competition has little chance of success. The scientist's contribution to the Planning team is, therefore, his awareness of new technology and his ability to visualize its applications for new products. He must also provide proof of feasibility by exploratory research, to enable the planners to set reasonable targets, but, at the same time, sufficiently advanced to be challenging to the product designer. Setting these technical objectives is not a one-way street, as the product developers and marketing managers are continually

demanding something new and better from the basic researchers. To be specific, the developer may see a need for transistors with improved noise characteristics. This sparks fundamental or applied research to determine more about the cause of noise in semiconductors. If the demand is urgent, results are usually forthcoming. In the communication industry this co-ordinated approach for new objectives is constantly raising the standards for such items as reliability, signal to noise ratios, increased power output and faster operating times for transistors, improved memory storages, and many other fundamental characteristics of communication equipment.

Research Management in Canada

The broad objectives of increased profit and close co-ordination with other management interests do not differ in Canada from those in the United States, but specific project objectives present a very different challenge to Canadian research management. It is estimated that United States is presently spending over $15 billion on research and development, nearly half of our total G.N.P. Canada's expenditures are about $350 million, so we have two entirely different economies. We must also consider our different climatic conditions, our scattered population and, in many cases, the small volume manufacture.

The Canadian consumer is forced, in many instances, to accept products of American design, even though they are manufactured in Canada, whether or not they suit the specific conditions or economic environment here in Canada. As for example, the automotive industry does little to provide corrosive-resistant material to stop rust pinholes in our fenders after the first winter season. Only a small proportion of the population in the United States is concerned and therefore the matter gets meager attention; nor does the automobile manufacturer give adequate consideration to defrosting facilities. Should a booster battery at a cost of a few dollars be standard equipment for all Canadian cars instead of the luxury of an automatic gearshift which is actually a liability on our ice and snow-covered streets? Statistics[4] show that 170,520 automobiles were imported into Canada during 1960, which is 35.6% of the total domestic consumption, whereas United States[5] only imported 6.7%. Detailed breakdown of the statistics is not available but there is no doubt from what we see on the streets that most of the Canadian imports are small economy cars without frills and gadgets. This is what our Canadian customers want and it would appear that the Canadian automobile manufacturer has ignored our economic conditions and requirements. Have the Canadian TV designers considered the manufacture of a single-channel inexpensive set for frontier location where one broadcast station will be the ultimate in luxury? Certain types of industries predominant in our Canadian economy, such as deep mining and paper making require special electrical equipment. Are the Canadian designers providing these requirements, or does the customer have to accept a standard American design produced for the mass market in the United States?

The research and development organization of the Northern Electric Company has obtained extremely rewarding results by designing equipment to meet the specific requirements of our small and scattered communities and supplying communication services to the barren frontier areas in the north. We have provided modern automatic communication switching offices for communities as small as 400 subscriber lines, and work is continuing to provide even smaller offices for communities with as few as 60 lines. The smallest central office designs available from the Bell Laboratories in the United States, incorporating the most modern features, were economical only down to about 1000 lines until Northern's development became available, and they show no interest in our smaller offices under 400 lines. Currently we are about a year ahead of the American system in the United States. Our first installation went into service early this year. We have provided special microwave radio systems for communication in the far north where stations can be separated as much as 250 miles, where access over rugged terrain is extremely costly, and would be economically prohibitive if we used the standard U.S. communication systems which are normally line of sight and spaced about 20 miles apart.

Many more examples could be provided to show how Canadian research and development has supplied equipment to meet the specific requirements of Canadian conditions and economy, but these two serve to illustrate that there is a real challenge for industry to be independent. It not only returns a worthwhile profit to the company concerned, but also supplies the Canadian consumer with the type of product he needs. The specialized equipment also opens up increased possibilities of exports, as there are many of the smaller developing countries who require similar types of equipment, which are not satisfied by the large American producers.

Conclusion

In conclusion, Canada is facing a real challenge to maintain its position as an industrial nation in the face of ever-growing competition from foreign sources. This challenge can only be met by the development of increased technical competence by industry. In view of our limited economy, we cannot compete in all fields with the major nations, but a well-planned research and development program directed toward the requirements of our Canadian economy, will enable us to build up our internal trade by supplying Canadians with the type of goods and services they require. These specialized products should open up foreign markets which have been neglected by the major producing nations. We can no longer be copiers but must provide products which are distinctive to Canada and our type of economy.

The Northern Electric is obliged to provide equipment which is compatible and capable of working with 70 million telephones in the United States, but experience has shown that it does not need to be identical. The results of our research and development organization during the past few years have been most encouraging. To be successful, new product development in itself is not sufficient; a large amount of basic research is beyond the financial capabilities of our economy but applied research is essential. The hard cold facts of profitable product innovation depend on the rapid application of new arts. This is applied research, and with well defined objectives the challenge to our Canadian scientists is direct and the results will be extremely rewarding.

References

1. National Industrial Conference Board Publication on Economic Growth in the 1960's.
2. National Science Foundation—**Funds for Research and Development in Industry 1958**—NSF 61-32.
3. The Conference Board—**The Economic Almanac 1962**—Page 93. National Science Foundation—**Review of Data on Research and Development** Nos. 24—Dec. 1960, and 30—Sept. 1961. Her Majesty's Stationery Office, London—**Annual Report of the Advisory Council on Scientific Policy 1959-60**—Cmnd.1167. Dominion Bureau of Statistics—**Federal Government Expenditures on Scientific Activities 1958-59**—Catalogue No. 13-515, plus estimate for Provincial Governments, Universities and Non-Profit Organizations. Dominion Bureau of Statistics—**Industrial Research**—Development Expenditures in Canada 1959—Catalogue No. 13-516.
4. Dominion Bureau of Statistics—Canadian Statistical Review Dec. 1961—Catalogue 11-003.
5. U.S. Department of Commerce—**Bureau of Business Economics Survey of Current Business Vol. 41 No. 12**—Dec. 1961.

BEECHWOOD GENERATING STATION —

Installation of the Third Unit

G. E. Gunter,
The New Brunswick Electric Power Commission

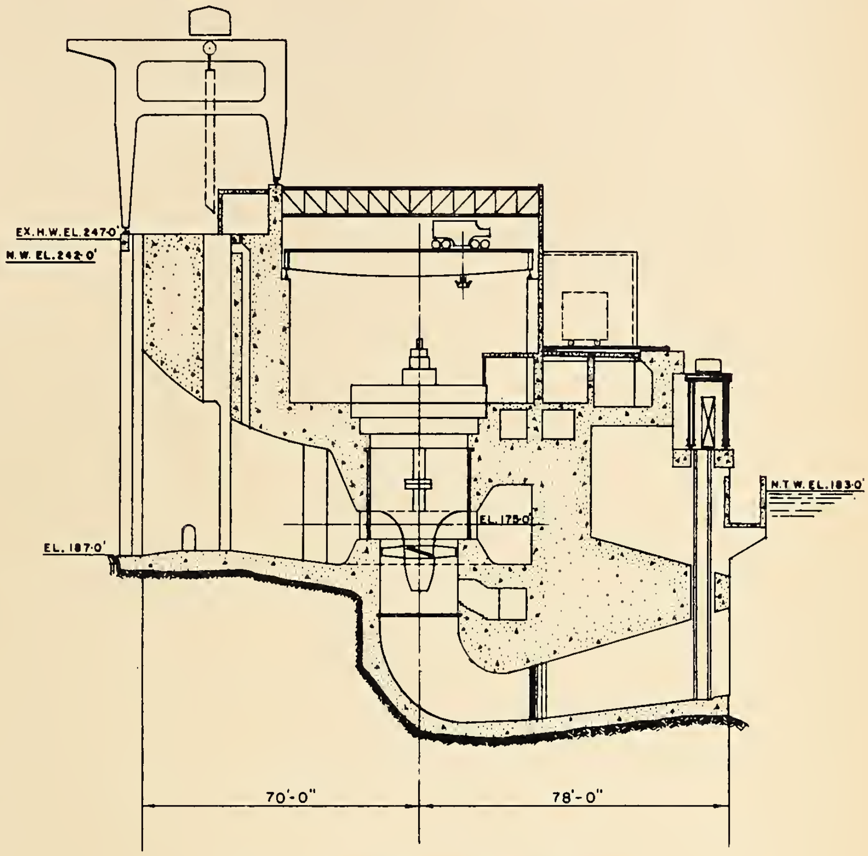
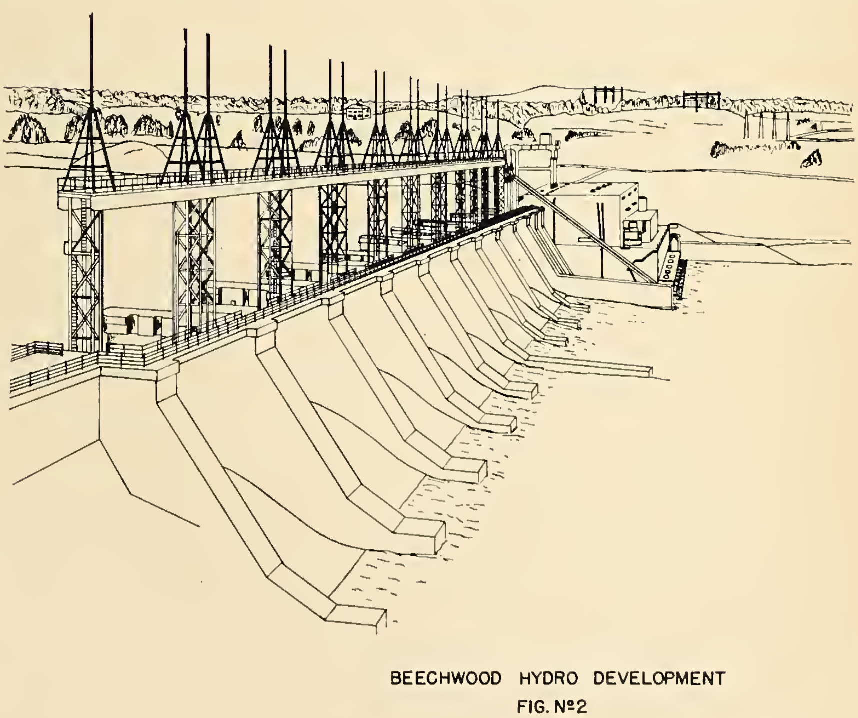


Fig. 1. Section Through Power House.

THE Beechwood Generating Station of The New Brunswick Electric Power Commission is located on the Saint John River about 65 miles northwest of Fredericton. The station is of the integral powerhouse type; the total length of the concrete gravity dam and powerhouse being 1000 ft. There are nine spillway sections and two control sections in the dam with a combined design flood capacity of 412,000 c.f.s. Figs. 1 and 2 show the general arrangement of the station.

Headpond elevations at the dam vary from 233 ft. to 242 ft. and tailrace elevations range from 180 ft. to 206 ft. Water flows at the station vary from 1000 c.f.s. up to a maximum recorded flow of 238,000 c.f.s. Fig. 3 "Annual Flow Duration Curve" and Fig. 4 "Beechwood Head Curve" further serve to illustrate the extremely wide range of operating conditions at the station. Beechwood is then a "run of the river plant" in the truest sense of the word.

The generating plant at the station was originally intended to consist of three Kaplan turbines rated at 45,000 h.p. at 57 ft. head. These units drive 40,000 kva. umbrella type generators. Unit No. 1 was commissioned in December, 1957, with Unit No. 2 following in March, 1958. The turbines were, at that time, the largest Kaplan turbines in Canada. It was planned to install the third unit when



BEECHWOOD HYDRO DEVELOPMENT
FIG. №2

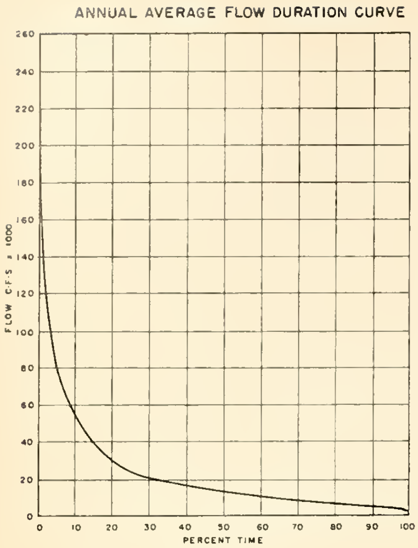


Fig. 3.

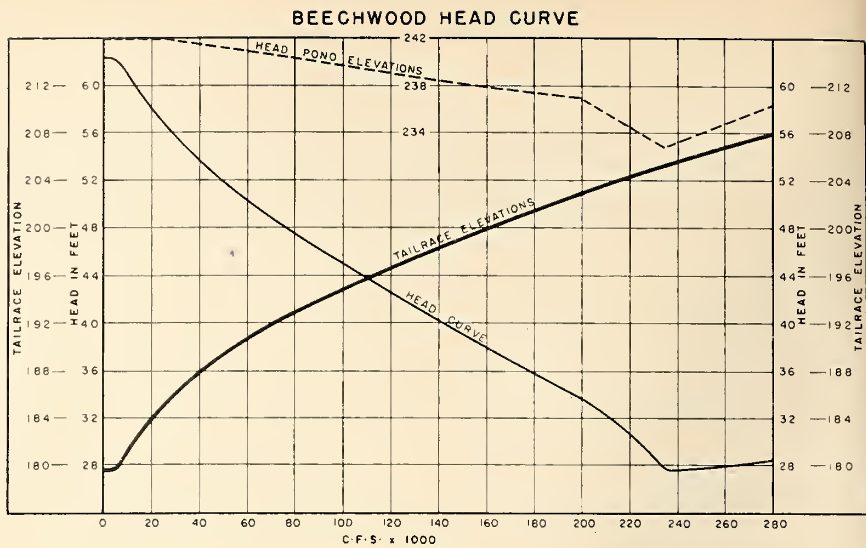


Fig. 4.

system conditions warranted such an addition in hydro capacity.

SYSTEM CONDITIONS

The New Brunswick Electric Power Commission system is composed of approximately equal amounts of hydro and thermal generating capacity. During the high flow periods that exist in the spring and fall the hydro stations are base-loaded and the peaks are taken with thermal units. In summer and winter, however, when river flows are low, the situation is reversed; the most efficient thermal units are base-loaded and the hydro units perform the peaking duties. It can be seen therefore, that our hydro units are not only required to run over a wide range of heads and flows but also they must function in both base load and peaking capacities. This type of operation together with the rather low heads naturally suggests the use of Kaplan turbines. A closer look, however, shows that the average summer and winter flows are below the capacity of the first two Kaplans. This leaves the third unit to operate only in the spring and fall, and indicates the possible use of a fixed propeller turbine. A study conducted in 1958 which showed that the installation of the third unit could be justified as early as 1961 instigated a closer look at this matter of turbine type.

ECONOMIC STUDY

Preliminary examinations were inconclusive as the differences in generation that could be predicted for the two types were of a much smaller order than the suspected errors in the assumptions that were made. It became apparent that the accuracy of the studies would have to be ±1% and that the only way to obtain this

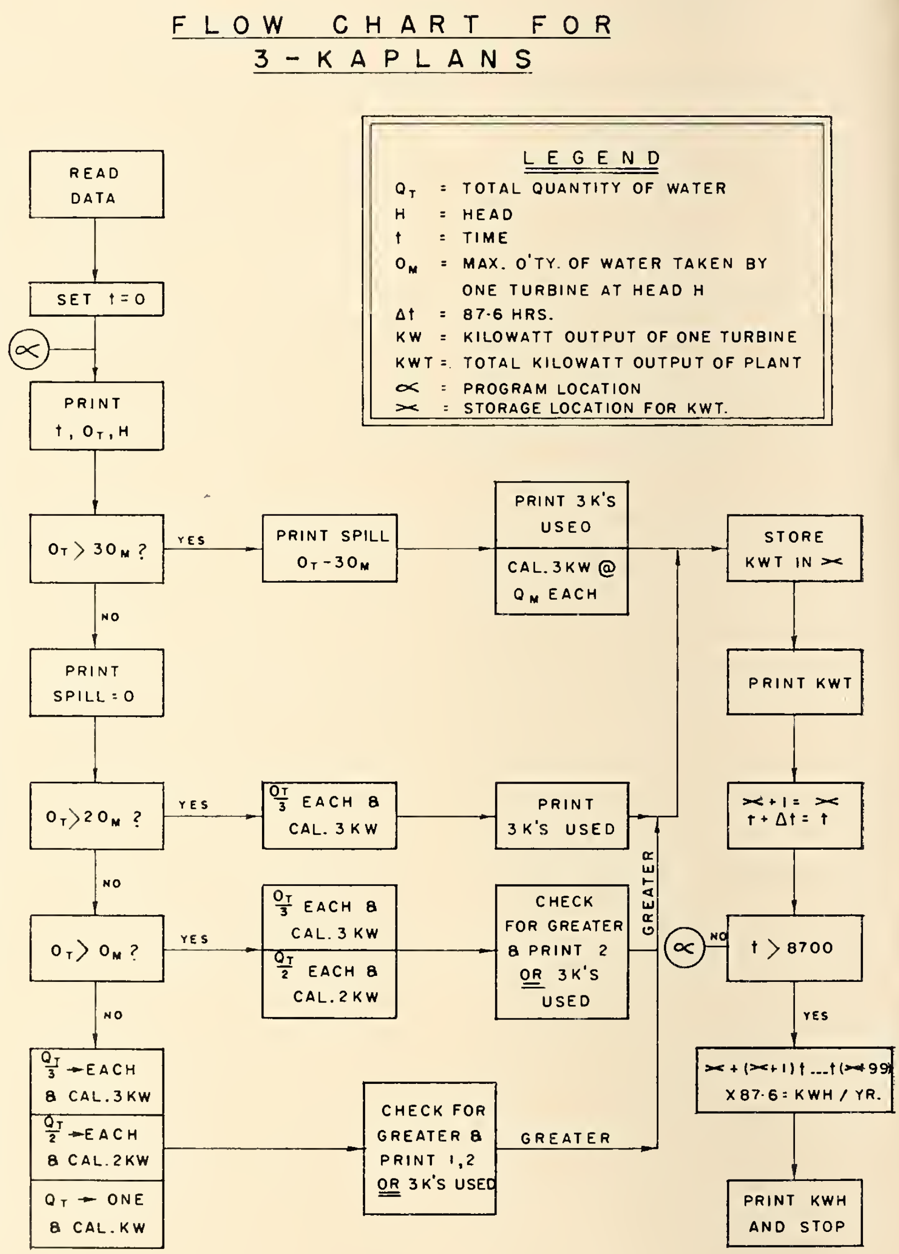


FIG. 5

accuracy would be to actually duplicate the operation of the plant for the flow and head conditions existing throughout the year. A scheme was devised where the annual flow duration curve was divided into equal parts; each of which representing the flow existing for 1% of the year. The corresponding head was taken for each flow increment. The generation from each head-flow condition would be calculated for the station using various types and sizes of turbines for the third unit. The units would be loaded in the most economical manner. This last condition was the most difficult to satisfy since while it is relatively easy to predict the most economical loading sequence for identical units it seemed the only way this could be done with different units was through a time consuming "cut and try" procedure. Fortunately the University of New Brunswick had just purchased a digital computer. This fairly small general purpose computer is ideally suited to engineering problems of this type. It was therefore decided to write a program for the turbine study.

Performance curves of several Kaplan and fixed blade propeller turbines ranging from 45,000 to 50,000 hp. were obtained and translated into the mathematical language of the computer in the following manner.

An equation was written for each of several curves of kw. output vs. flow for various heads. For Kaplan turbines these were parabolic equations and for fixed blade propeller turbines they were two straight lines.

An example for a Kaplan is as follows:

$$H = 60 \text{ ft.}; KW = aQ^2 + bQ + C$$
$$H = 55 \text{ ft.}; KW = a_1Q^2b_1Q + C$$
$$H = 50 \text{ ft.}; KW = a_2Q^2b_2Q + C$$

Where:

KW = Kilowatt output
Q = Flow to the turbine
H = Head
a, b, c = coefficients

The coefficients were then expressed as a function of head by similar parabolic equations.

$$a = xH^2 + yH + z$$
$$b = pH^2 + qH + r$$
$$c = 1H^2 + mH + n$$

Where:

x, y, z, etc. are coefficients.

Similarly, the maximum output from the turbine was expressed in terms of the flow as a function of head.

$$Q_{max} = eH^2 + fH + g$$

Where:

e, f, g, are coefficients.

A similar equation was found for the intersection of the two straight lines describing the performance of the fixed blade propeller turbines.

The above equations were all prepared manually. Curve fitting programs which have since been obtained for the computer would have greatly simplified and improved the accuracy of this portion of the work.

Three programs were written for the study. The first was for a scheme using a third Kaplan turbine identical to units one and two. In this program it was assumed that whenever more than one unit was operating, each unit would carry the same load. This assumption is valid for the specified accuracy.

The second program was for schemes with the third unit a fixed blade propeller turbine. The third program which was actually only a variation of the second was used for schemes with the third unit a Kaplan turbine not identical to the existing units. Figs. 5, 6 and 7 are flow diagrams for the three programs.

The following is a description of a typical run for a scheme using a large Kaplan turbine. The performance data for the turbines and the flows and heads are read into the computer. The computer prints the first river flow, Qt its corresponding head, H, and the time. (Time is used only as an indication of the progress of the run.) The maximum flows for the units are calculated at Head H. If these are less than the total flow Qt, the spill is printed, generation for each unit is calculated, and printed and the total generation is calculated and printed. If there is no spill Qt is compared with the maximum flow through the existing units. If Qt is greater than this, then the flow through the third unit is set

FLOW CHART FOR 2 KAPLANS &
1 FIXED BLADE PROPELLER

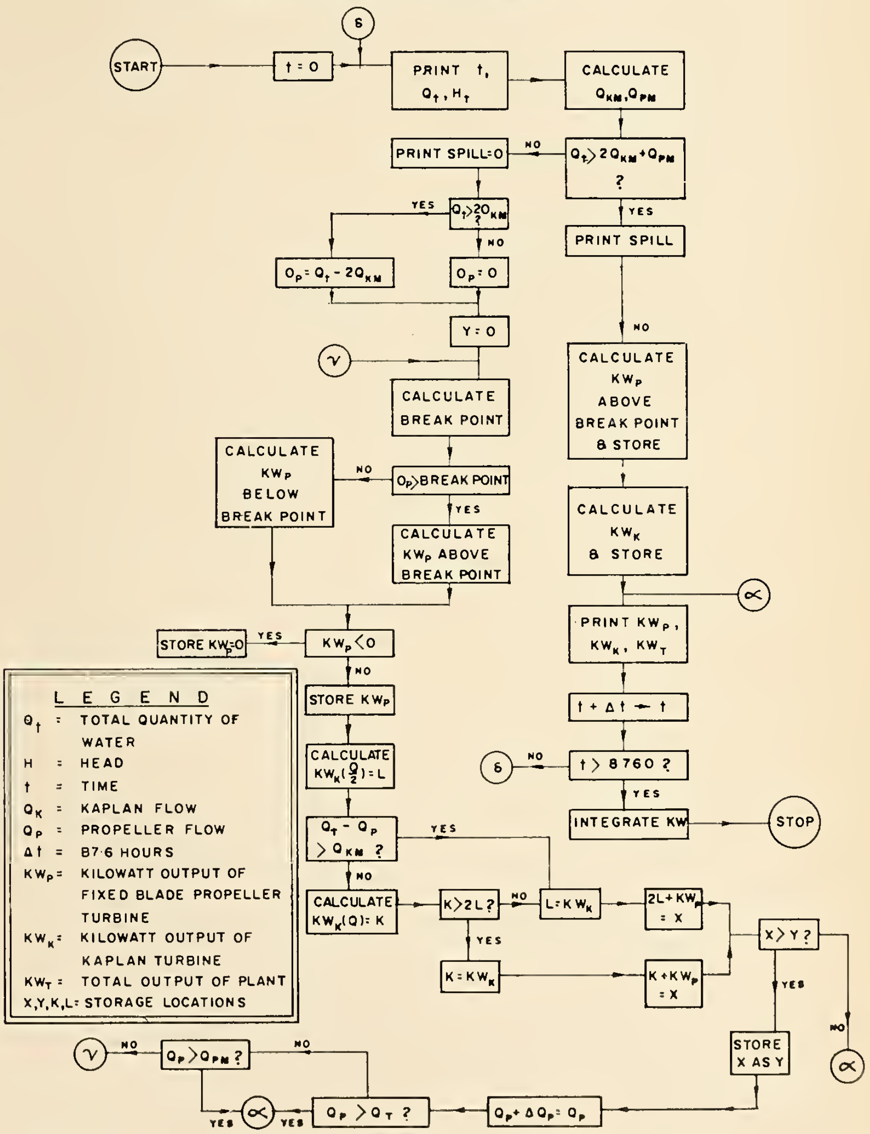


FIG. 6

as the difference between Qt and the maximum flow through the existing units. If Qt is less than the maximum flow through the existing units then the flow to the third unit is set at 0. In either case, the generation from the third unit is calculated and stored.

When the flow to the third unit has been established, a sub check is made on the operation of the existing units. If the flow to them is less than the maximum flow for one unit the generation is calculated for both one and two unit operation. The larger figure is stored as the generation from these units. The total plant generation is then calculated and stored.

The flow to the third unit is then increased by 250 c.f.s., the flow to the existing units reduced by the same amount and the plant generation recalculated. If this value is greater than the previous value, the new value is stored in its place. The flow to the third unit is again increased by 250 c.f.s. and the calculation repeated. If this generation is less than the previous value, the previous figure is printed as the generation at that time and the next increment of river flow is considered in the same manner. Checks are made each run to see that no negative values of generation are stored or printed and to insure that no unit is loaded above its maximum load.

When each of the 100 increments of flow have been considered, the generation from each increment is totaled, the sum printed and the program stops.

Generator and transformer efficiencies were taken as 97% and 99% respectively for all units and all loads, a simplification which produces a negligible relative error.

Energy was evaluated at 5 mills per kwh. and capacity at $18 per kw. per year. These are average values for the N.B.E.P.C. system. When the energy and capacity evaluations were compared with the annual cost of owning and operating the various third units, a cost advantage of $12,000. per year emerged in favour of a large fixed blade propeller turbine over all other units. The second most economical unit was a similar sized Kaplan turbine. This difference appeared to be due mainly to the higher efficiency of the fixed blade propeller turbine at or near full gate and to a lesser degree to its lower initial and operating costs.

As was stated previously, the predicted error in the study was ± 1%. When this was applied to the calculated generations of the two schemes in question, the $12,000. figure was reduced to a practically negligible $2,000.

The N.B.E.P.C. did not at that time operate any fixed blade propeller turbines, however, some consultation with utilities who do, tended to confirm our own feelings, that from an operating standpoint, these turbines are not ideally suited to the wide range of flows, heads and unit loads that they would experience at the Beechwood Station. This coupled with the fact that the cost advantage for the fixed blade propeller turbines was rather low resulted in a decision being made to install a third Kaplan turbine. Accordingly, bids were called for a unit identical in size to the existing machines and alternatively on the largest Kaplan turbine that could be installed in the Beechwood setting. The machines proposed ranged in size from 220 in. diameter to 240 in. diameter and in rating from 49,000 hp. to 59,000 hp.

The computer program was used to evaluate the bids. In general, the order of the evaluation was in the order of increasing size; first choice was the 59,000 hp. turbine and a 55,500 hp., 230 in. diameter machine was second. Since the size of these units was somewhat larger than had been anticipated, the matter of operating such large machines in the Beechwood setting was examined fairly closely. It was found that the water velocities that would exist in the draft tube were in excess of what was generally considered to be a maximum value for water over concrete and hence erosion could be a problem.

A limit of 30 ft. per second was imposed on the average velocity in the tube and this eliminated the number one choice in the evaluation. The company which proposed the 55,000 hp. machine stated it would

FLOW CHART FOR 3 KAPLANS
ONE LARGER THAN THE OTHER TWO

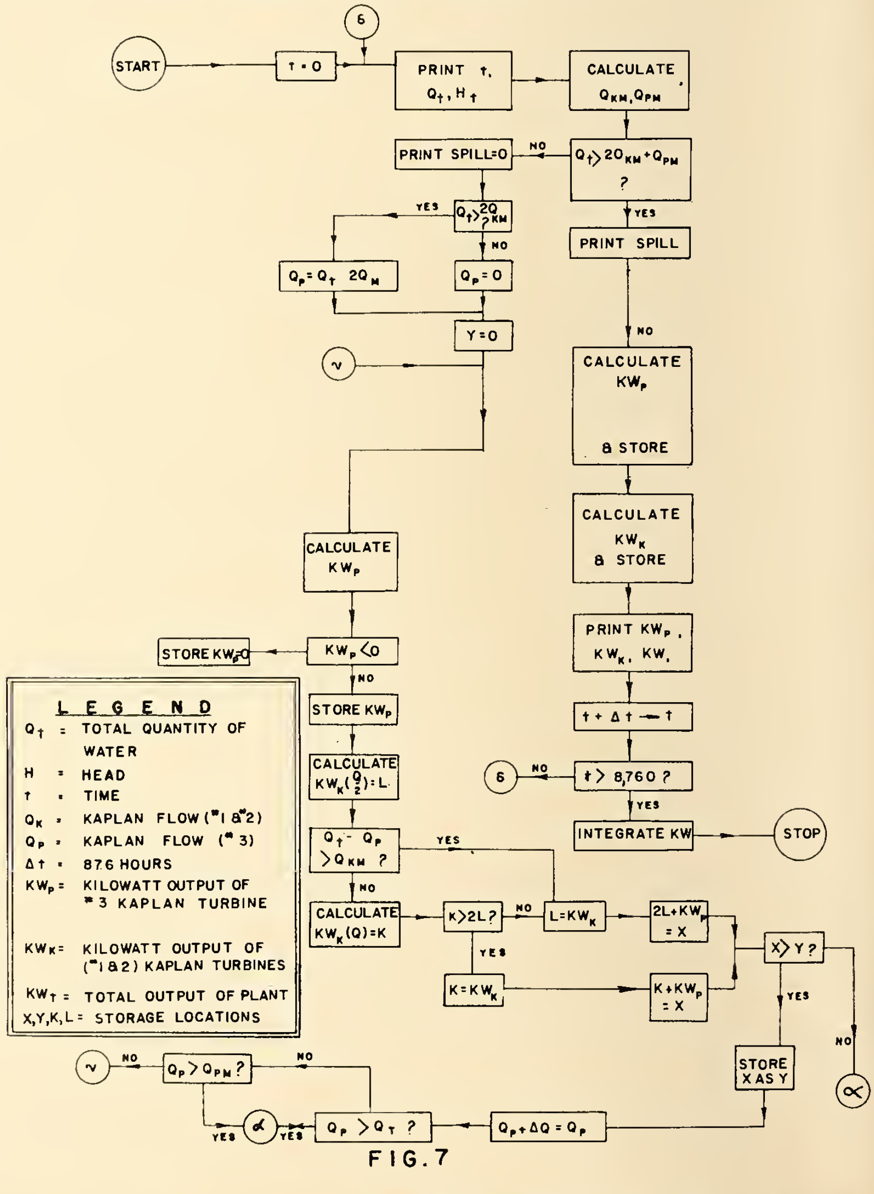


FIG. 7

extend its steel draft tube liner a short distance to a point where the 30 f.p.s. limit would not be exceeded and were given the order for the turbine. A 45,000 kva. generator was puchased. The difference between generator and turbine ratings was somewhat less than had been used by the Commission up to that time. The reasoning for this was that the design of turbines and generators had progressed to a point where the maximum capacities of these machines seldom exceed their ratings and hence large margins were essentially capacity paid for but never used. The governor for the third turbine is an A.S.E.A. Electrohydraulic type similar to those used on Units 1 and 2. All the various electrical systems and the cooling, lubricating and service system in the existing plant were extended to include the third unit. A second 138 kv. single circuit transmission line was constructed between Beechwood and Fredericton and the necessary modifications made to the switching stations at either end.

MODEL TESTING

Shortly after the order was placed for the turbine the manufacturer proceeded to conduct tests using homologeous models of both the proposed runner and the existing draft tube.

The results of the initial tests were extremely poor. Even after some initial problems were solved, the efficiencies of the model combination remained at a level some 10% lower than the guaranteed values. This problem turns out to be one facing all prospective purchasers of reaction turbines for which an existing draft tube was not specifically designed. There are three basic reasons involved in this matter of turbine-draft tube incompatibility. First, if the turbine is larger than that anticipated in the draft tube design, the overall velocities existing in the tube will be higher. Second, again if a larger turbine is used, the contours at the neck of the tube must be changed. The third reason applies whether the new turbine is larger or not and is that the distribution of velocities leaving the runner will probably not be the same as was originally counted on. Aside from the fact that the larger water quantities result in higher friction drops in the tube, these three factors can have a detrimental affect on efficiency if they create any tendency toward separation of water flow from draft tube wall. The very low test efficiencies achieved tended to indicate that this separation problem was present in the combination of existing Beechwood tube and the new turbine.

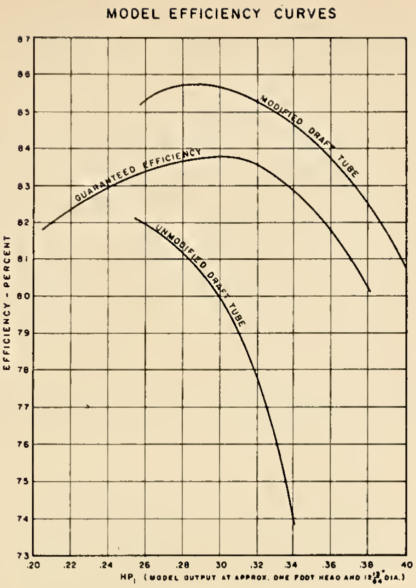


Fig. 8.

In general, this separation occurs on the inner curvature of the elbow of the tube, and in some cases can be carried downstream a short distance. The standard method for eliminating the separation is to reduce the cross-sectional area of the tube at this location and hence decrease the rate of deceleration of the water and in some cases to actually increase the rate of flow. Naturally, the existing draft tube had this reduction in area, however, the company elected to experiment with an increased "pinch" effect. They proposed to reduce the cross-sectional area at the elbow in two ways. First, the width of the tube was reduced by fillets on either side. Secondly, a fillet was applied to "roof". The results of the first tests with the modified draft tube were gratifying. Successive tests using variations of the original modification resulted in raising the efficiency to a level well above the guarantee. Figure 8 shows the change in efficiency resulting from the modification. In addition to the increase in efficiencies, the maximum power and the cavitation characteristics were considerably improved over those attained with the unmodified tube.

The design of the modifications on the prototype draft tube was begun immediately after the completion of tests. Several methods were discussed including complete steel plating of the revised surfaces and a complete concrete job. The scheme finally chosen was as follows. The fillets in the side walls were done in reinforced concrete. The reinforcing consisted of a mesh of ⅜ in. bars on 12 in. centers behind a 4 in. cover and one row of ⅜ in. horizontal bars on 8 in. centres. The whole mass of concrete was secured to the existing draft tube walls with ⅜ in. rods set in cinch anchors on 36 in. centres. An area, 18 in. wide and 4 in. deep was chipped out around the perimeter of each fillet to eliminate any feather edges. When the forms were stripped, this perimeter area was rechipped to a section of about 6 in. wide and 2 in. deep and a fillet of epoxy base concrete applied by hand. The roof modifications were formed by ¼ in. steel plates shaped to the new contour and secured to the existing concrete by rods and cinch anchors. The void behind the plates was pressure grouted.

The delays in the field erection schedule resulting from the draft tube problem necessitated a rather unusual erection procedure. Since the turbine design could not be finalized until the draft tube situation had been resolved, the delivery of this item was set back about two months from the original schedule. This meant that the generator could be on the site some time before the turbine. The erection scheme devised was as follows. The turbine stay ring, discharge ring, draft tube liner and pit liner were installed. Next all the concreting work including the completion of the scroll case, draft tube modifications and the setting of generator sole plates was done. The generator stator which had been pre-wound was set in place. The turbine head covers, wicket gates, shifting ring and bottom ring were then placed. The next phase of the work was the complete erection of the generator including shaft, bearing, rotor, upper and lower brackets, air casing and exciters. At this time, some of the oil head assembly was also fitted. The partially assembled turbine runner arrived on site just as this work was completed. The generator was then dismantled and the head covers placed on the runner which was then placed in the pit. The generator was then reassembled.

The scheme saved about one month in erection time since all the time consuming fitting work involved in the initial assembly of the generator was done during a non-critical part of the schedule. The final assembly of the generator was completed in about one week. The extra costs incurred by this scheme were easily justified when the saving in time was evaluated in terms of lost energy.

FUTURE ADDITIONS

The Beechwood station is now complete as was originally conceived. There are, however, two schemes which have been considered for further increasing the station capacity.

THE ISOLATION OF THE BUILDINGS IN THE PLACE VILLE MARIE DEVELOPMENT FROM RAILROAD-INDUCED VIBRATIONS

J. E. Brett, M.E.I.C.
Principal, Brett & Ouellette, Consulting Engineers, Montreal

THE PLACE VILLE MARIE Development represents the culmination of four years of effort in the working drawing and construction stages. It can most easily be described in terms of the design and construction phasing of the project as follows:

Phase I: The 41-storey, cruciform-shaped Royal Bank Building, with its Plaza and lower levels covering a plan area of approximately 93,000 sq. ft.

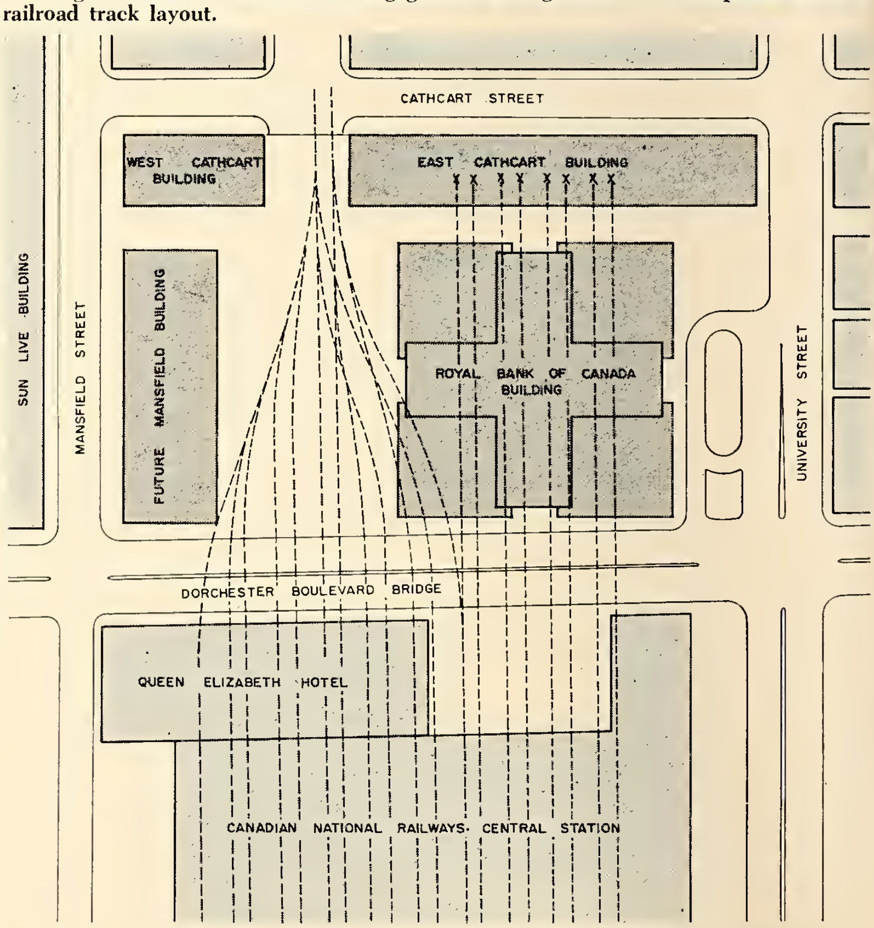
Phase II. The lower levels over the remainder of the site, covering an area of some 250,000 sq. ft., together with the three-storey Cathcart Building and the projected 10-storey Mansfield Building.

The site of this project overlies a large portion of the Canadian National Railway Central Station railroad yard in downtown Montreal. The inter-relationship of the project phases and the principal adjacent structures is shown in Fig. 1. The prestige nature of the project made it imperative that further understanding of the cause and control of railroad-induced noise and vibration than was heretofore readily available be obtained. It is hoped that this work may be of use to others.

Noise and Vibration

The disturbance to the building occupants arising from the train movements may take the form of an unduly high vibration or noise, or both. The work "vibration" will indicate a structure-borne vibration, which, if sufficiently intense, may be "felt" by an occupant. The term "noise" will indicate a vibration "heard" rather than "felt". Since is it difficult (essentially impossible) to make complete data analyses during the short time of a train passage, magnetic tape recordings were made of all events and the records were analyzed later for noise and vibration intensity as a

Fig. 1. Plan view of site showing general arrangement of Development and the railroad track layout.



function of the frequency composition of the signal.

Railroad Practice

The use of built-up lead-asbestos isolator pads to minimize disturbances in terminal buildings has been standard practice with North American railroad companies for some time. The pad is made of two ⅜ in. thick layers of asbestos separated by a 1/16 in. sheet of galvanized steel and encased in a watertight envelope of ⅛ in. sheet lead. The asbestos component may vary from a soft fire-felt to a hard board depending upon the contemplated application. The pad is precompressed under a pressure of 200 p.s.i. and has a bearing capacity varying from 600 to 1000 p.s.i., depending on the form of the asbestos. Isolator pads of this type were installed in the foundations of the Queen Elizabeth Hotel, the asbestos being in the form of a cement-asbestos board. The data on the damping characteristics of the pads for design purposes was not found in the literature and was approximated from the measurement program outlined in the following section.

The Measurement Program

An extensive program was carried out at the site by the acoustical consultants on this project during February, 1959, to obtain data on the generation and transmission of railroad-induced noise and vibration into the contemplated structures. Tape recordings were made at various locations of the effects of more than 200 train movements in order to ensure statistical validity of the results with respect to the many variables in the problem. The records were later analyzed to determine the noise or vibration level in each of the frequency bands.

The generation of these disturbances was found to be affected by the following variables:

a) Train speed. Some train movements were at "platform-speed" and some at "yard-speed".

b) Equipment. Axle-loads of locomotives generated higher energy levels than those of the lighter cars.

c) Width of rail-joints. Noise arising from the presence of the main-rail-joints was found to be sufficiently high to warrant the taking of corrective measures.

d) Switches and frogs. Single-point frogs were found to be the most serious noise and vibration generators in this project.

e) Ballast. The solidly-frozen condition of the 2 ft. thickness of rock ballast overlying bed-rock undoubtedly had some effect on the measurements, although no quantitative studies were made to determine the influence of this factor.

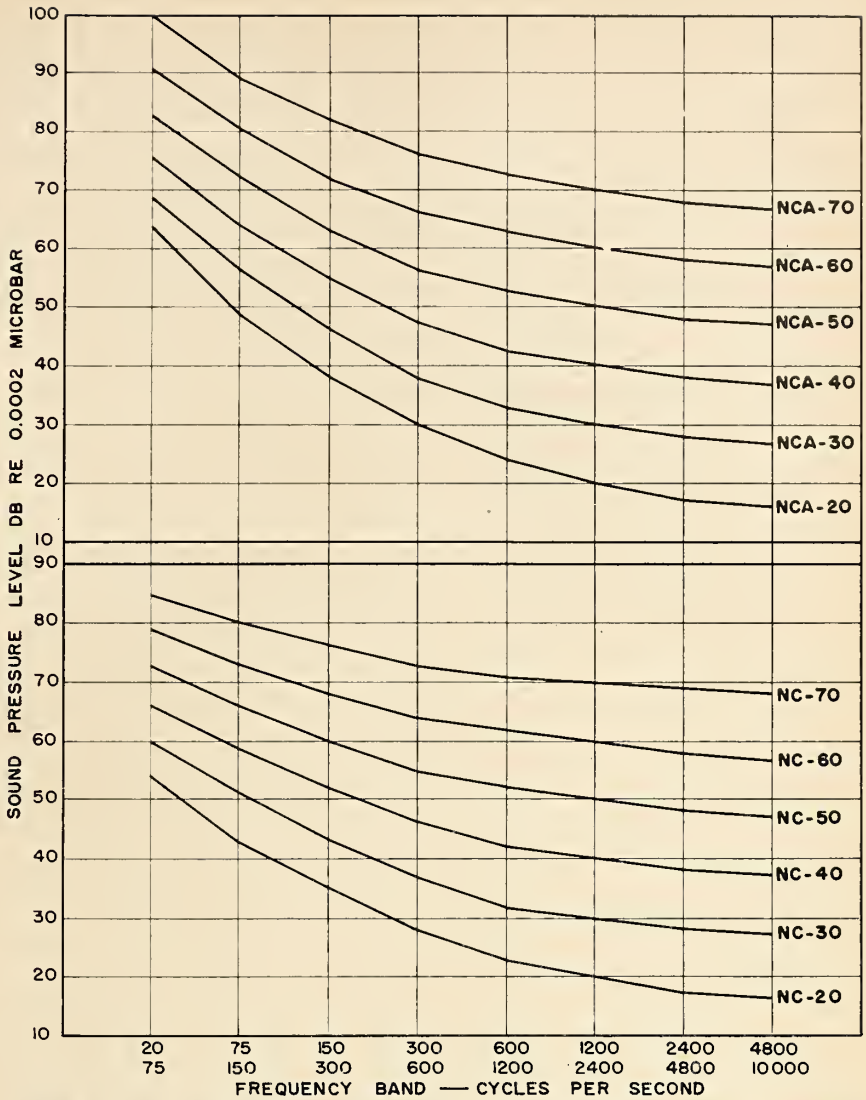


Fig. 2. "NC" and "NCA" noise criteria curves as per Bolt, Beranek & Newman Figures 1 and 2 of their final report.

The transmission of the disturbances was studied with respect to the horizontal and vertical distances from the tracks and the presence or absence of isolator pads in the adjacent structures.

The program consisted of the measurement of the following effects:

a) Earth - borne railroad - induced vibration.

b) Structure-borne railroad-induced vibration in the isolated Queen Elizabeth Hotel and the unisolated Dorchester Street Bridge.

c) Radiated noise in the hotel and bridge structures.

Three different arrangements of measuring equipment were used. In the first system used to record vibrations, the output of a Bruel and Kjaer accelerometer was connected through a bandpass filter to a vacuum-tube voltmeter to provide a direct-reading instrument in the sub-audio frequency bands of 2-4 cps, 4-8 cps, 8-16 cps, 16-32 cps and into the higher frequency audio bands. In the second type, comprising two complete systems, the output of each accelerometer was recorded on a magnetic tape and analyzed in the normal audio frequency bands of 20-75 cps. 75-150 cps, 150-300 cps and continuing up to 10,000 cps. The third system was used for radiated noise level measurements and comprised a microphone, sound level meter and octave band analyzer selected to cover the audio bands from 20 cps to 10,000 cps.

Consistent with the variety of conditions to be imposed by the Development, vibration measurements were made at 20 different locations ranging vertically from track level to elevations of 110 ft. above and horizontally over distances exceeding 200 ft. As a general rule, both the horizontal and vertical components of vibration were measured at all stations. Also, the two tape recorder systems were

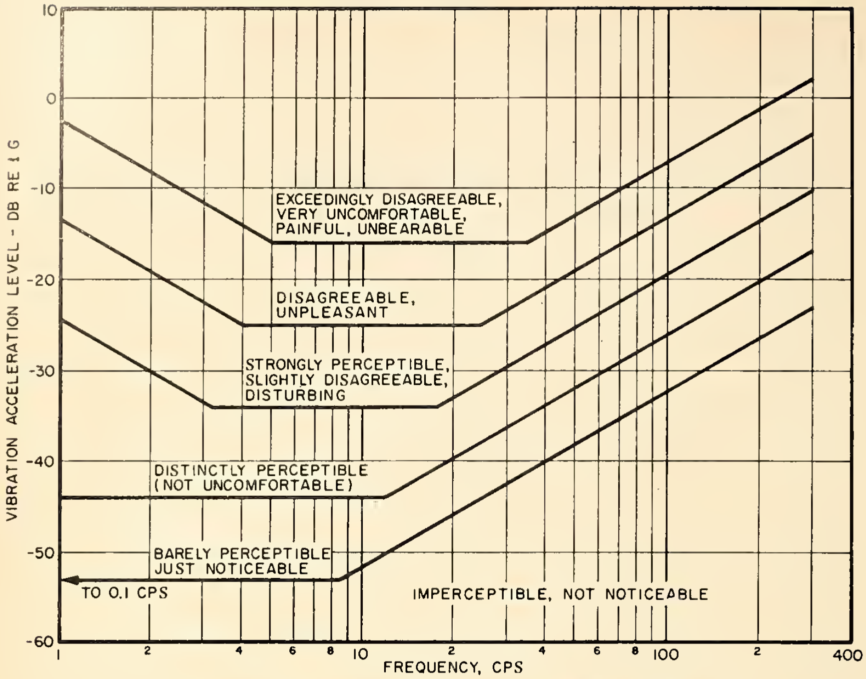


Fig. 3. Response of humans to vibrations as per BBN Figure 5.

operated simultaneously so that the same event would be recorded on each system, the only differences being the intentional differences between the particular pick-up points. In this way it was possible to accurately assess the vibration level differences that could be attributed to the measurement position differences. An important part of the program concerned the study of the effectiveness of the vibration isolator pads as used under the columns of the Queen Elizabeth Hotel. Many simultaneous recordings were made with one pick-up on an isolated Hotel column and one on an unisolated Bridge column

Human Response to Noise and Vibration

It will be appropriate at this point to briefly discuss a few acoustical terms.

The noise in any environment is usually described by a graph of the sound pressure level as a function of the frequency distribution of the noise. The family of noise criterion, "NC", curves shown in Fig. 2 describe noise conditions judged to be acceptable by the average person for various situations. Human acceptance of these values is based on our acceptance of the balance of the sound pressure levels of the several frequency components of the noise. Noise becomes a disturbing element if such balances are not met, within reasonable limits, or if the absolute sound pressure levels are appreciably higher than the ambient noise levels in the space considered.

It has been found possible from acoustical studies to tolerate somewhat greater pressures of low frequency noise than indicated in the "NC" curves. The alternate noise criterion curves of Fig. 2 may then be used. The use of these alternate values may be considered in the design stages because of the preponderance of low-frequency sounds in railroad-induced noise, the practical impossibility of their complete removal from the noise spectrum and last, but not least, their intermittency for the major portion of the normal office day.

The noise and vibration design criteria for the Royal Bank Building varied with the intended occupancy. The steady-state ambient noise levels in the executive offices and conference rooms were to lie in the range of the NC-25 to NC-30 curves. The noise levels in private offices were to lie in the NC-30 to NC-35 curves. The noise levels in the large, open office areas not involving business machines were to lie in the NC-35 to NC-45 curves. For those areas involving business machines, the levels permitted corresponded to the NC-45 to NC-55 curves.

Fig. 3 summarizes the response of human beings to vibration. To verify the numerical values, train passages were found to be heard, but not felt in a fifth-floor hotel room. The measured vibration levels were in the range between −65 and −70 db re Ig in the 20 — 75 cps and 75-150 cps bands. The numerical values were thus found to be applicable.

Measurements

As previously indicated, extensive measurements were made to evaluate the contribution of each of the several factors to the noise and vibration environment to which the Development would be exposed. The vibration-isolated hotel, the unisolated bridge and the active railroad yard permitted the establishment of reference conditions and the measurement of data necessary to proceed from an existing structure to one in the design stages. Low levels of low frequency sound are more easily heard than the corresponding sound-producing vibrations are felt. For this reason, measurements were made of the noise levels rather than the vibration levels.

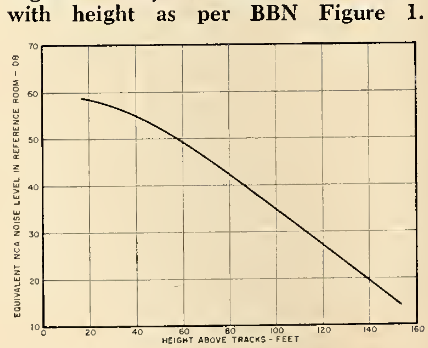
Effect of Height above Track Level

Radiated noise levels resulting from train movements at platform speeds on conventional track, without switches, were measured in hotel areas at different elevations, interest being taken in the frequencies between 20 and 600 cps. The areas were acoustically dissimilar and the measured noise levels were converted to equivalent levels in the reference room. Each equivalent noise level was then related to the highest NCA curve that had at least one point in common with it. The decrease of railroad noise levels with height for an isolated building was thus obtained and is shown for this project in Fig. 4.

Effect of Speed

It was found more difficult to isolate the effect of speed. Appreciable differences in the acceleration rates of the trains, different switch settings and differences in the rolling stock combined to mask this effect. It was noted that the vibration levels measured near platforms increased moderately with speed between the time the locomotive and the last car passed the measurement position. Trains travelling at yard speed were judged to be appreciably noisier than those travelling at platform speed and trains starting or stopping were judged to be somewhat less noisy than those at platform speed.

Fig. 4. Decay of railroad noise level with height as per BBN Figure 1.



Track Joints and Switches

The measurement of noise levels arising from track components gave interesting results. The passage of a wheel over a track joint appeared to be somewhat noisier than a wheel running on ordinary track. The welding of track then can be of importance.

Of greater importance was the fact that the passage of a wheel over the gap of a single-point frog appeared to be at least three times as noisy as that of a wheel over a track joint. It was estimated that the installation of a moving-point frog would offset the major portion of this increase.

Effect of Distance

The natural damping of vibration with distance was found to be of real significance with respect to this project. Also, during the working day, train movements tend to occur generally on widely-separated tracks, thus reducing the noise pressure at any one point in the building.

Isolator Pad Effectiveness

From the scientific point of view, the determination of the efficiency of the lead-asbestos isolator pads was of the greatest interest, since published data on their damping characteristics was not available. Three unisolated columns of the bridge structure and three adjacent isolated columns of the hotel structure provided a satisfactory setting for this investigation. These columns are situated in the vicinity of Track 7 near the western edge of the railroad yard. The measurements confirmed the usefulness of this type of pad in general, although some of the results were unexpected.

At Track Level

The first series of measurements were made near track level to determine the horizontal component of vibration of each of the six columns due to train passages on tracks at varying distances. It was found that the results did not follow any simple law and they merit further discussion. The vibration levels for the isolated column in the 20-75 cps band were found to be slightly lower at small distances and appreciably lower at larger distances than for the unisolated column. In the next higher frequency band of 75-150 cps, the vibration levels for the isolated column were slightly higher at small distances than those of the unisolated column. At the larger distances, the results were essentially the same as for the first frequency band. This result indicates that the natural frequency of the isolator pad lies in the frequency band of 75-150 cps. The isolator pads appeared to be less effective in the higher frequencies. For example, in the 150-300 cps frequency band, the difference in vibration levels was again slight for small distances and only moderate for a distance of 200 ft.; in the 600-1200 cps frequency band, the differences in levels was small over the full range of distance. This was not considered to be serious on this project, since most of the energy emanating from railroad vibration is concentrated in frequencies below 300 cps and the energy contained in the higher frequency vibrations is readily absorbed in a normal building structure.

At Higher Elevations

The vertical components of vibration were next measured at higher elevations of these six columns. The vibration levels were found to be moderately lower in the 20-75 cps band, considerably lower in the 150-300 cps band and slightly lower in the 300-600 cps band, for the isolated column than for the unisolated column. These values were recorded at the first floor level above the tracks during the passage of a commuter train on Track 7; similar, but slightly lower differences were found for the passage of a diesel switcher on Track 11 at a lateral distance of 100 ft.

These results indicated that the isolator pads afforded some reduction of structure—transmitted noise and vibration. The measurements showed an isolation effectiveness of the pad ranging from 2 db to 12 db, depending upon distance, frequency and other factors. For purposes of design on this project, an average value of 8 db was selected. The reader is cautioned against an acceptance of this value for use on other projects without further consideration. Differences in column spacing, pad composition, structural details and geometry are a few of the many factors which may give rise to variations in this numerical value.

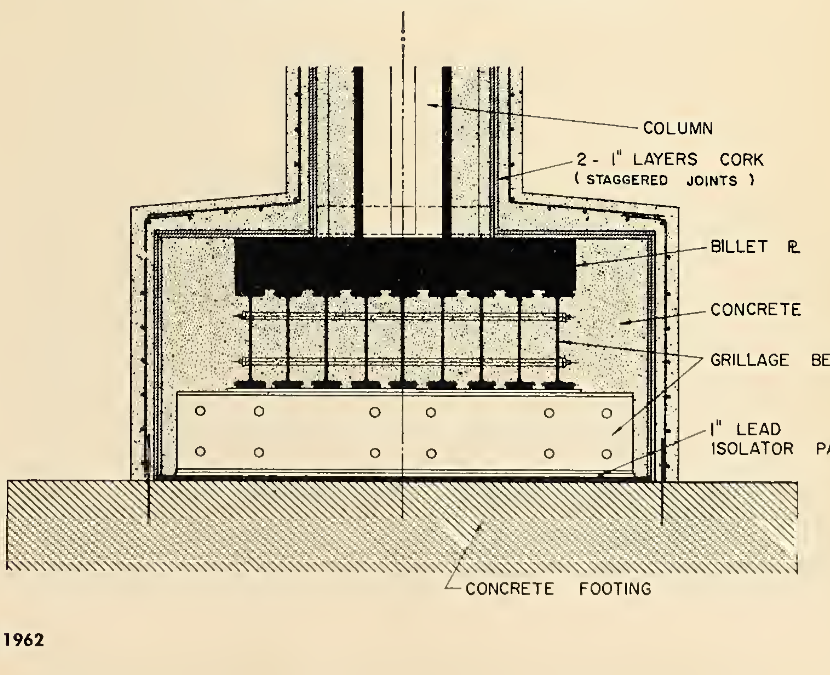
Noise Level Computations

The forecasting of the noise level to be expected from railroad activity in any occupied space of the Development consisted of the integration of the individual effects discussed above. The integration consisted of a series of corrections to the equivalent NCA noise level given in Fig. 4 for the height of the particular space above track level. Certain noise control recommendations were included in the calculations. The recommendations were formulated during the design stages and are summarized as follows:

a) *Isolator pads.* The installation of isolator pads between the column grillages and the tops of the footings was carried out for the majority of the columns throughout the project. Studies of certain columns at large distances from tracks and supporting noisy-occupancy areas revealed the complete feasibility of omitting isolator pads at these locations and this was done.

The asbestos component of the pads installed under the Royal Bank Building took the form of cement-asbestos board. This building is essentially to one side of the higher-speed tracks. The asbestos component of those pads more directly over the

Fig. 5. Typical footing isolation details.



higher-speed tracks took the form of fire-felt asbestos. Although the fire-felt pads are probably somewhat superior acoustically to the cement-asbestos pads, they were designed to function under compressive unit loads of 600 p.s.i. as contrasted to the 900 p.s.i. working unit loads of the latter. The loads of the tower columns, in excess of 12,000 kips, were one consideration in this choice. It should also be mentioned at this time that the exterior vertical and top surfaces of the concrete footings, the grillages and the columns to elevations above railroad platform level were encased in two one-inch-thick waterproofed layers of cork. The cork was later encased in 4-in. of protective concrete. For those footings directly below tracks, the upper surfaces of the footing and grillage were isolated with lead-asbestos pads in place of the cork.

b) *Double-spring frogs.* It will be recalled that open-gap frogs were found to be the most offending component of trackage in the yard. It was recommended that three such frogs nearest the office areas be replaced by the much quieter double-spring frogs. The double-spring frogs reduce the track gap and hence the noise as the wheels pass over them. Since these frogs can swing in both directions, the reduction is valid for both directions of travel.

c) *Track Welding.* Consistent with the measurements, the welding of straight tracks and low-curvature curved tracks was carried out throughout the yard.

d) *Project Separation.* The structural framework of the project was separated from adjacent structures to avoid the introduction of secondary paths of noise or vibration transmission. Resilient joints were provided across this separation in the way of pedestrian or vehicular crossings.

Pad Installation

The relatively flexible nature of an isolator pad made careful workmanship necessary during the planing procedure of the upper concrete surface of the footings. This was accomplished in the usual manner with a machined steel screed sliding on accurately-leveled and machined supports. Two coats of black asphaltum paint were placed on the concrete to prevent any possible chemical action between it and the lead sheath of the pad.

The magnitudes of many tower column loads gave rise to grillages of large linear dimensions. The lower grillage beams of the heaviest tower columns, for example, covered an area of approximately 9 ft. by 11 ft. Dimensions of this order resulted in the fabrication of the isolator pad in segments for all of the larger footings. The joints between the segments were sealed with industrial tape 2 in. in width to prevent the interstitial grillage concrete from forming vibration paths through them. The details of a typical installation are shown in Fig. 5.

Conclusions

The studies outlined in this paper offer a sound approach to the resolution of a complex problem. The result indicated to the designers that a satisfactory solution was achieved within the scope of normal construction procedures. It is hoped that this paper may be of use to others in this field.

Acknowledgements

The author wishes to express his deep indebtedness to Laymon N. Miller of the firm of Bolt, Beranek and Newman Inc., acoustical consultants on this project, for his painstaking work during this study and to I. M. Pei, architects, for permission to use the quoted data.

Dear Fellow Member:

Your Council is pleased that you and your fellow members in the Engineering Institute of Canada saw fit to vote on the amendments to the By-laws, recently put before you, in such a decisive manner. This augurs well for the future of your Institute. It also indicates, I believe, that you endorse the observation made in "Mr. Member! About That Fee Increase" which appeared in The Engineering Journal for August, 1962.

Nevertheless, a number of you voted against the amendment covering dues, as well as the other By-law amendments. Your views are respected by all of us.

However, I sincerely trust you will accept the majority view and act in accordance therewith when you receive your dues invoice later on in the year.

I can assure you that your Institute is ready to provide all members with the highest quality services and facilities which so many members want. Your warm co-operation will make it possible for the Institute to be of the greatest possible aid to you, Mr. Member—to be truly outstanding in meeting your needs.

Yours very truly,

F. L. Lawton, M.E.I.C.
PRESIDENT

Cher confrère,

Votre Conseil est heureux que vous et vos collègues membres de l'Institut canadien des ingénieurs vous soyez prononcés d'une façon si concluante au sujet des amendements aux règlements, qui vous ont été soumis récemment. Cela est de bon augure pour l'avenir de l'Institut et indique également, j'en ai l'impression, que vous êtes d'accord avec les observations faites dans l'article paru dans le numéro d'août 1962 du périodique de l'Institut, initulé "Au sujet de la hausse des cotisations".

Toutefois, un certain nombre de membres ont voté contre l'augmentation des cotisations et autres amendements aux règlements. Nous respectons tous leur point de vue. J'ai confiance, cependant, qu'ils se plieront de bon gré à la voix de la majorité et qu'ils se mettront d'accord avec leurs collègues quand ils recevront leur facture plus tard cette année.

Je tiens à vous réitérer que l'Institut est désireux de fournir à tous ses membres le meilleur service possible. Votre collaboration permettra à l'Institut de vous être de plus en plus utile et de se montrer vraiment à la hauteur pour répondre à tous vos besoins.

Veuillez agréer l'expression de ma considération la plus sympathique.

LE PRESIDENT,

F. L. Lawton, M.E.I.C.

Discussion

MAGNETIC INVERTERS

H. R. Campling, M.E.I.C.,
Associate Professor,
Department of Electrical Engineering,
Queen's University, Kingston

J. A. Bennett, A.M.E.I.C.,
Lecturer,
Department of Electrical Engineering,
Queen's University, Kingston

D. H. O'Hara, M.E.I.C.,
Junior Research Officer,
Radio and Electrical Engineering
Division,
National Research Council, Ottawa

The Engineering Journal, July, 1962, page 40

Discussion by :
W. Howard Card
Department of Electrie Engineering
Syracuse University,
Syracuse, N.Y.

This paper reviews the behavior of a class of polyphase transistor inverters. The authors provide a useful explanation of the operation of these inverters and they correctly point out the importance of transformer leakage reactance. It should be emphasized that close coupling between the two main windings labeled N_1 is the critical requirement. This follows because energy stored in the leakage reactance associated with each N_1 must be dissipated in the transistor when it is turned off. If the two N_1 windings were perfectly coupled this problem does not arise.

Figure 13 in the paper shows an interesting way of eliminating the usually-undesirable steps in the slave-oscillator output-voltage waveform, and the always-undesirable steps in the slave-transistor base-drive voltage. The synthesis of a sinusoidal wave from square-wave components shown in Fig. 17 provides a sort of converse of the Fourier representation of square waves by sinusoidal components. Other variations of the basic circuit are reported also.

The principal contribution of this paper, I believe, is the experimental results for the transient behavior of the two-phase inverter. These results illustrate the explanation previously reported by Campling and Bennett of how a stable equilibrium relationship between master and slave inverter is reached. Start-up behavior of these inverters is not always the same, of course, because of the residual magnetic flux density in the cores; however, it is only the relative phase of the two inverters that has the possibility of a settling time greater than one cycle, and this is the problem treated by the authors.

The resistively-loaded two-phase inverter has a phase relationship somewhat like the position of a simple pendulum. The pendulum has two equilibrium conditions (one up and one down), only one of which is stable.[1] Similarly, in the simplest two-phase inverter of the type under discussion there are two equilibrium conditions: the slave inverter may lead the master by 90 degrees or it may lag by 90 degrees. Only one equilibrium is stable. The analogy with the pendulum breaks down, unless the pendulum is at least critically damped because there is no overshoot with the inverter.

In the experimental results shown the maximum time to reach essentially stable equilibrium is about 10 cycles. With other initial conditions reported, the transient time was less. Presumably it could also be more and theoretically even approach infinity. From given initial conditions of core flux, the settling time depends on design parameters but the possibilities of a very long settling time remains.

The nature of this transient raises a question not discussed by the authors. Since the work reported was for resistive loads no special problems arise; however, if a two-phase inverter is used to drive a single two-phase induction motor it is observed that phase-locking may not be necessary between master and slave inverters once the machine is going. That is, the motor, not unexpectedly, provides its own phase· locking. Now there is the possibility that (with the motor running backwards) the self-stabilizing action of the induction motor may be sufficient to hold the inverter at what would be an unstable equilibrium for resistive loads.

In conclusion, several extensions of the work reported here might provide interesting problems for the authors or others. First, if silicon controlled rectifiers (SCR's) could be used in place of the transistors, the practicable upper limit on power could be raised by 10 or 100. Second, rather than trying to make inverters with sinusoidal output, why not investigate the behavior of loads with square-wave drive?

[1]The term stable and equilibrium are employed in the usual sense of nonlinear mechanics, i.e., stability in the sense of Liapunoff. See e.g., N. Minorsky "Non-Linear Mechanics" J. W. Edwards, Ann Arbor (1947), p. 41.

Discussion by :
A. E. Maine
Editor, Electronics and Communications

The systematic examination that the authors have made concerning the general class of magnetically phase-locked magnetic multivibrators will be much appreciated by those working in the static power conversion field. However, the following question and observation arises in this reader's mind:

Toward the end of the article a description is given for fabricating a near-sinewave output by means of summing squarewave sources mutually phased in some desirable manner. I have done a considerable amount of theoretical and experimental work in this direction and in fact have produced a rather complicated expression for determining the optimum phase angles for any number of sources. However, in cases where more than two sources are summed, "Forced" forward and/or reverse currents occur in the collectors of the power transistor groups considerably degrading their otherwise desirable operating loci. Countermeasures to combat this situation were found to be complicated and involved extra losses to the extent that it was concluded that the entire method for obtaining near-sinewave outputs was not really practical. I should like to know if the authors have been able to get around this problem satisfactorily.

I should like to comment, by the way, that brute-force filtering of inverters outputs does indeed sound rather an unattractive proposition . . . however, it turns out that with these methods hundreds of VA of "5% distortion limited" power for an increase in weight equivalent to only about 40% of that of a single output transformer, and still at a good efficiency, can in fact be achieved.

Discussion by:
W. J. Moore, M.E.I.C.
and M. P. MacMartin
National Research Council
Ottawa

Professor Campling and his associates have provided a most interesting analysis of the operating cycle and have described some ingenious circuits for obtaining multiphase operation and waveform control. With the advent of new direct current power sources, such as fuel cells and thermoelectric generators, these circuits are becoming more and more important and their studies will, we are sure, prove to be of great value.

Not having direct experience with these devices, we cannot say very much which would add to the paper. However, there are a few questions which we would like to put to the authors.

1. The description of the switching process given in the paper is probably the most complete that has yet been offered. Some difficulties still arise, however, if attempts are made to explain the division of magnetizing current or the effect of load variation. Of particular interest is the interval when both transistors are in the conducting state. During this period, only one transistor (that which is going on) carries the load current while apparently both carry magnetizing currents. Can the authors say what factors govern this division or how point L in Fig. 3a is located?

2. The scheme proposed for approximately sinusoidal waveform and three-phase output should certainly satisfy those who object to square waves. The objectives have apparently been achieved with considerable elegance and simplicity. The interconnection of the output windings from several individual inverters must result however in periods where the flow of load current through some windings is in a direction opposite to that called for by the output voltage of the corresponding inverter. Since the transistor is essentially a uni-directional device, what measures should be taken to permit this reverse load current to flow without undue restriction?

3. Also, the authors have implied that circuits are available which make use of controlled rectifiers in place of transistors. The operation of the controlled rectifier is somewhat different from that of the transistor however, and presumably a different form of control is required. Can the authors

(Continued on page 112)

Canadian Steel Improvement technician setting up for X-ray test of complete Canadair casting.

Exposure technique for small castings.

KODAK INDUSTRIAL X-RAY FILM provides castings with the all-important stamp of approval

Canadian Steel Improvement Limited, Toronto, manufacture castings and forgings for the varied products of more than 150 customers. Their customers' lines range from aircraft engine parts and automotive components to refrigerator equipment and portable pumps. "We constantly use radiography for both proof of quality and pride of workmanship", explains F. B. Pillman, sales manager. "X-rays assure us that the parts are sound and meet specifications. We could test by sectioning, but that would destroy the casting. To omit radiography is false economy because a defect may be uncovered later during expensive machining processes."

In some instances 100% radiography must be made of certain components. For example, each of the 130 pound castings for a naval radar system was shot from 40 angles. Of course, few castings are as complex to test. In the case of the two ounce electronic computer components, the castings had to be radiographed from only two angles, and several castings could be shot at the same time.

"For castings of uniform thickness, and most particular thin sections, KODAK Industrial X-Ray film, Type M is used because of its high contrast and extra fine grain", says William Douglas chief radiographer for Canadian Steel Improvement Limited.

"KODAK Type AA film is exposed where higher speed is required for the heavy complex sections. The two films are an ideal combination for checking at a single exposure, both thin and heavy section of a complex casting."

KODAK Industrial X-Ray film is job oriented to guarantee results. Contact your X-Ray dealer or Kodak Technical representative for the full story. Or write to:

CANADIAN KODAK CO., LIMITED, Toronto 15, Ontario

Kodak
TRADEMARK

Month to Month

BRIGHT FUTURE FOR THE INSTITUTE UNDERLINED AT DIGBY COUNCIL MEETING

Stirling, Heartz Agree to Head Headquarters Building Committee

Two prominent past-Presidents of the Institute have agreed to head a committee charged with seeking adequate accommodation for Headquarters.

Co-chairmen of the Committee of Institute Building Program are Dr. J. B. Stirling and Dr. R. E. Heartz, both of Montreal.

Approval for the formation of the Committee was given during the March 10 meeting of the Executive Committee. Present Headquarters accommodations were recognized as unsuitable, and inconsistent with the "image" of the Institute.

R. E. Heartz, M.E.I.C.

J. B. Stirling, HON. M.E.I.C.

Determination of current and future needs for suitable facilities in Montreal will be the first charge of the Committee. It then will review existing facilities to determine whether they can be made adequate at a sensible cost.

Capital and operating costs of suitable Headquarters premises are to be reviewed, and the Committee may suggest methods of financing such premises.

A possibility to be pursued is the procurement by the Institute of suitable Headquarters facilities in leased premises under a long-term lease. It would also determine the capital and operating costs of such leased premises. The Committee also may engage consulting services, subject to approval by the Finance Committee and Council.

Institute Communications Reorganized On Regional Lines

The rapid growth of the Institute has caused Council to establish regional information and co-ordination centres to provide for easier and more effective communications between Branches and the Institute. This plan is designed to

Presidents or Senior Officers of the Commonwealth Institutions: left to right, Back row: S. Rajanayagam, Institution of Engineers, Ceylon; G. H. Woods, South African Institute of Electrical Engineers; C. E. Spearing, Institution of Chemical Engineers; J. H. Pitchford, Institution of Mechanical Engineers; Sir George McNaughton, Institution of Civil Engineers; Major-General R. H. J. Risson, Institution of Engineers, Australia; P. L. Laing, New Zealand Institution of Engineers; C. J. Hopewell, South African Institution of Mechanical Engineers; J. E. Mitchell, Rhodesian Institution of Engineers; Tuan Yusoff Bin Haji Ibrahim, Institution of Engineers, Malaya; G. S. C. Lucas, Institution of Electrical Engineers. Front row, left to right: R. D. Hawkins, South African Institution of Civil Engineers; F. L. Lawton, The Engineering Institute of Canada; Major-General Harkirat Singh, Institution of Engineers, India.

G. McK Dick, M.E.I.C.

ensure an effective flow of information and opinion among the far-flung segments of the Institute.

Council approved this reorganization after it was recommended by the Committee on Planning for the Future. Chairman of this vital committee is past President Dr. McK. Dick.

According to this scheme, Canada will be divided into 10 regions serving as information and co-ordination centres. This will allow for compact, effective meetings of regional and Branch officers. It is proposed that a least one senior officer from each Region will attend meetings of Council or of the Executive Committee.

Council approved this plan in principle, but decided that it be given a two-year trial period before any permanent decision is considered.

In line with this new policy a regional information and co-ordination meeting was scheduled for October 27 in Regina. Invited were Councillors and Branch Chairmen of Zone "A". Chairmen of Standing Committees were asked to attend to explain the work and the future plans of their committees.

First Meeting in Canada of Commonwealth Institutions

The Conference of Engineering Institutions of the British Commonwealth met in Canada for the first time this year. The meetings which were held in Montreal, Quebec City, Ottawa, and Toronto, with a side trip to Niagara Falls, took place from September 9 to September 21.

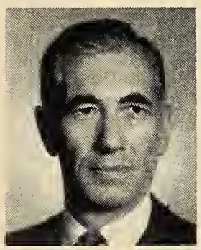
Representatives of more than 200,000 professional engineers of the Commonwealth concerned themselves with the freedom of movement of professional engineers between Commonwealth countries, and the freedom with which professional engineers qualified in one Commonwealth country may practise in other Commonweath countries.

The Conference of Engineering Institutions of the British Commonwealth held its first meeting in the United Kingdom in 1946 and since has met at four-year intervals in South Africa (1950), London (1954), and Australia and New Zealand (1958). The 10 countries in the Conference were represented by the Presidents and Secretaries of the appropriate national engineering institutions. The EIC was host this year.

Discussions centred on such subjects as common rules for professional conduct, standards of professional qualification, reciprocal arrangements for membership between Commonwealth Engineering Institutions, the statutory registration of professional engineers compared with voluntary membership in a professional body, relations with other international groupings of professional engineers and matters concerned with the constitution of the Conference.

These discussions led to a greatly increased understanding of procedures and practices and to the adoption of a number of recommendations, the effect of which should be a more efficient exchange of professional engineering practice among Commonwealth countries.

The deliberations were stimulated by the great engineering developments taking place in Canada, some of which the delegates visited. They enjoyed the generous hospitality of Canadian engineers, industry, faculties of engineering, and the National Research Council of Canada.



C. G. Kingsmill, M.E.I.C.

General Secretary Announces New Staff Appointment

The General Secretary is pleased to announce that Grange Kingsmill joined the EIC Headquarters staff October 1 as Manager of Technical Services. In this capacity his major responsibilities will be in furthering the work of the Committee on Technical Operations at both the national and Branch levels, and with some of the technical aspects of the EIC publications program.

Mr. Kingsmill has been a member of the Institute for 35 years. During this time he has served as a member of the Montreal Branch Executive, currently as Chairman. He has served on Council, and was Chairman of the 1956 and the 1962 Annual Meeting committees.

Before joining the EIC Mr. Kingsmill was connected with many major construction projects, including the Beauharnois and Warsak hydro-electric developments. During the last 10 years he was with Angus Robertson Ltd., prior to which he was Chief Engineer, Power Development Division, Hydro Quebec.

H. G. Conn, M.E.I.C.

DEAN CONN REPRESENTS EIC AT EUSEC MEETING

Dean H. G. Conn of Queen's University represented the Institute at the fourth formal meeting of the Committee on Engineering Education and Training of EUSEC. The meeting was held in London from June 25 to June 30. Host society was the Institution of Electrical Engineers of the United Kingdom.

EUSEC is the Engineering Societies of Western Europe and the United States. Canada is not a member but Dean Conn served as EIC representative-observer by invitation. American members are ASCE, AIChE, AIEE, ASME and AIME, and they designated the Engineers' Council for Professional Development as their representative on the Committee.

The six work sessions dealt with urgent education problems common to Western Europe and to most of North America.

F. L. Lawton, M.E.I.C.

PRESIDENT HEADS EIC DELEGATION AT ECPD

President Lawton led a strong EIC delegation to the Annual Meeting of the Engineers' Council for Professional Development which was held October 1-2 in Philadelphia. Other Institute representatives who participated in the extremely busy two days of meetings were Guy Savard, G. R. Henderson, Col. W. S. Wilson, Col. W. A. Capelle and General Secretary Garnet T. Page.

Participating societies in ECPD are the: American Institute of Chemical Engineers; American Institute of Electrical Engineers; American Society of Mining, Metallurgical and Petroleum Engineers; American Society of Civil Engineers; American Society for Engineering Education; American Society of Mechanical

Engineers; EIC; Institute of Aerospace Sciences; Institute of Radio Engineers; and National Council of State Boards of Engineering Examiners.

Major discussions were precipitated by the reports of the Committees on: Guidance; Education and Accreditation; Student Development; Development of Young Engineers; Recognition; Ethics and Information.

The EIC report, presented by Mr. Henderson, noted that the Institute maintained active representation to all ECPD meetings and that the EIC Council had been kept informed.

ECPD publications were advertised in the Engineering Journal. Professional Development courses were being offered by most EIC Branches, and the National Professional Development Committee met in Montreal in June.

Mr. Henderson told of the Institute's international activities in allied organizations. He spoke of increasing EIC programs directed towards engineering students.

Underlying the report was the feeling of rapidly-increasing participation by the Institute and its members in all activities designed to increase the value of engineers and engineering.

Work Sessions

I—"General Education Before Admission to Engineering Schools of University Level." A significant point in the papers and discussions at this session was that despite the disparity of systems in the various countries, use of the Report on Education and Training of Professional Engineers makes it possible to achieve some common understanding of the preparation prior to university entrance.

II—"Education at Engineering Schools of University Level." In response to a general emphasis of scientific and mathematical content of undergraduate courses at the expense of more traditional "skill courses" it is believed that more responsibility for practical training will be assumed by industry.

III—"Practical Training Before, During and After Engineering Studies." In continental Europe there is a greater insistence of practical training before and, during the university course than is customary in the United States. It is not apparent whether this trend will continue.

IV—"Post First-Degree Education." While in all EUSEC countries the doctorate is awarded soley on the basis of a successful research program, only in the United States are there requirements for formal courses in such a program. Elsewhere the doctorate is awarded on the basis of the research, plus examination by a committee to determine the student's proficiency in his field and in defence of his research.

In addition, the United States is the only country where there is large enrollment in formal courses leading to a second degree, such as a Master of Science. While practices in the other EUSEC countries vary there was general agreement on the desirability of formal courses leading to post-graduate degrees, and of short, non-degree courses for the development of practising engineers.

V—"Criteria for Professional Recognition." It was quite obvious that criteria for professional recognition varied widely among the EUSEC countries. However, there was general agreement that no matter how high the criteria were raised for the start of any professional career, the obsolescence factor is high unless some method of keeping up to date is adopted.

VI—"Whither Engineering Education?" There was general agreement that the education of an engineer must stress the fundamentals and be strongly oriented towards the sciences without somehow losing the engineering flavor.

It was stressed that the engineer must continue his education as a life-long process, and not end it with the completion of his formal education.

J. Vance, M.E.I.C.

INSTITUTE WELL REPRESENTED AT IMPORTANT HEMISPHERE MEETING

A strong EIC delegation attended the Seventh UPADI Congress which was held in San Juan, Puerto Rico from August 26 to September 1.

The Canadian delegates were: Institute President F. L. Lawton; past-President James Vance, a member of the UPADI Board of Directors; C. R. Vegh Garzon, alternate member for Canada on the UPADI Board; Dean H. G. Conn of Queen's University; W. H. Beaton; and Garnet T. Page, EIC General Secretary.

The membership of UPADI comprises the leading national technical associations of engineers in each of the 23 countries of North America and South America. The host institution at the San Juan meeting was the Colegio de Ingineceros, Architectos y Agrimensorea de Puerto Rico.

Mr. Lawton, elected a Vice-President of the Congress, participated in the work of its Co-Ordinating Committee. All members of the EIC delegation participated actively in each of the five special committees (Administration, Relations, Budget, Legislation, Technical Program) and in a number of round-table discussions, particularly that dealing with engineering education. The Canadian delegates met frequently to compare notes and ensure maximum coherence and contribution.

The general concensus was that this was the most productive UPADI Congress to date. It is anticipated that the program resulting from it will be of real value. Greatly improved relationships were established between the EIC and UPADI generally, and between the EIC and the individual engineering societies.

A great deal was learned about how Latin American engineers operate, their problems, and how Canadian engineers can help in the fields of education, engineering and industry. That Canadian engineers have a much greater role to play in the work of UPADI and in Latin America generally, became apparent at the Congress. Continued EIC membership in UPADI is felt fully justified.

By improved knowledge and personal contact the Canadian engineering profession, through the EIC, can and should play a more effective role in Latin America.

OVERWHELMING BY-LAW APPROVAL, PUBLICATIONS EXTENSION HIGHLIGHT EXECUTIVE COMMITTEE MEETING

Resounding approval to proposed changes in the Institute's by-laws, and a progressive new scheme to expand the publication of technical papers were among the highlights of a meeting of the Executive Committee held in Montreal September 29.

Expanded Publications

The immediate results of the new publications plan will be more top-quality papers will be published with very little time lag.

Under the present system, papers which have been found technically suitable for publication must "wait in line" behind a large back-log of other papers which had been accepted for regular issues of either the Engineering Journal or of Transactions. According to the new system, all acceptable papers will be published in one of the three following media:

1. The Engineering Journal, which will continue to be published each month. Featured will be a larger variety of shorter papers of current interest to a wide cross-section of Canadian engineers.
2. Transactions of the EIC, which will be published as separate papers dealing with research, development, experimental work and the advancement of theory, of particular interest to those concerned with a field of engineering. Each paper will be identified as falling into one of five Series, and will be classified further within

each Series by the Technical Division covering the field of interest of the paper. Papers will be numbered consecutively within each Division. The five Series are:

Series "A" — Civil, Geotechnical, Bridge and Structural.
Series "B" — Mechanical, Welding, Thermal.
Series "C" — Electrical; Communications, Electronics and Automation, Hydro-Electric.
Series "D" — Management, Research, Education.
Series "E" — Chemical, Mining.

EIC Members may subscribe to any or all of the five Series by paying an annual subscription of $3 per Series. The number of papers per year in each Series will be about equal. Specially titled binders for each Series will be available from the EIC. The cost will be $3 each. Details about ordering Transactions will be sent to each member with his bill for 1963 membership fees.

Non-Members may subscribe to Transactions at an annual cost of $7 per Series, and may purchase binders at $4.

The Engineering Journal will carry advice of all Transactions papers as they are approved for publication. This will enable readers who have not subscribed to the Series in which a paper will appear to order a separate copy at a cost of 50 cents for Members and $1 for non-Members.

All Transactions papers will be included in the Engineering Index, and arrangements are being made with leading engineering libraries to maintain annual volumes of all Transactions papers on a permanent basis.

3. Division Papers will be published only as separate papers identified by the Technical Division covering the field of interest of the paper. These will be papers for which provision cannot be made for publication in the Engineering Journal or Transactions of the EIC, but which offer sufficient contributions to engineering knowledge by a Canadian author to warrant publication by the EIC. They will be numbered serially.

   The Engineering Journal will carry advice of all Division papers as they are approved for publication to enable readers to order them. The cost per copy will be 50 cents to Members and $1 to non-Members.

   All Division papers will be included in the Engineering Index, and arrangements are being made with leading engineering libraries to maintain annual volumes of Division papers on a permanent basis.

R. A. Phillips, M.E.I.C.

Publishing Objectives

This plan which will be put into practice in January, 1963, is the culmination of two years of intensive planning by the Publications Committee under Chairman R. A. Phillips.

Seven important objectives are hoped to be met by the plan. They are: to stimulate Canadian engineers to prepare more papers; to publish papers more promptly; to publish more technical papers; to divide Transactions into broad, logical technical areas; to help Members get more of the specific type of Transactions they want; to achieve the highest respect by authors and readers for Transactions; and to enable the Engineering Journal to become even more current, and of the widest possible interest to its readers.

Secretaries of the Commonwealth Institutions: Left to Right, Back Row: K. H. Platt, Institution of Mechanical Engineers, Dr. J. B. Brennan, Institution of Chemical Engineers; Lau Foo Sun, Institution of Engineers, Malaya; B. Seshadri, Institution of Engineers, India; Dr. G. G. Gainsborough, Institution of Electrical Engineers; A. McDonald, Institution of Civil Engineers; F. Jervis Smith, Institution of Electrical Engineers; S. Rajanayagam, Institution of Engineers, Ceylon. front row, left to right: A. J. T. Adams, South African Institute of Electrical Engineers; G. T. Page, The Engineering Institute of Canada; C. H. D. Harper, Institution of Engineers, Australia.

RESOUNDING ENDORSEMENT OF BY-LAW CHANGES

Corporate Members of the Institute were asked this summer to approve changes to certain by-laws. At least one of these changes—involving increased membership fees—was thought to be contentious. But by one of the biggest percentage of votes in Institute history every proposed change was approved overwhelmingly.

Increased fees were approved by about 80 per cent of those voting while other proposals received the endorsement of well more than 95 per cent.

New Fee Structure

In previous years Members were divided into three groups for billing purposes: Montreal Branch residents; all other Branch residents; and Branch non-residents and non-residents. Beginning in 1963 there will be no differentiation between Montreal Branch residents and residents of all other Branches.

Following is the new fee structure, in all cases with Branch non-residents and non-residents listed first, followed by all Branch residents.

Affiliates, $23 and 25; Students, $3; Associate Members, $12 and 14; Members, $22 and $24; Fellows, $22 and $24. Honorary Members will continue to be exempt from payment of annual fees.

In addition, entrance fees will be payable at the time of admission to the Institute, rather than at the time of application for membership.

Executive Committee, CBO and Committee on Membership Made Permanent

In recent years the rapid growth of the Institute has made it difficult to assemble a representative group of Councillors at frequent intervals. Because of this, and to ensure more prompt executive action, the 1960 Council approved the formation, on a trial basis, of an Executive Committee of Council.

This Executive Committee is composed of the President, the Vice-Presidnts, the immediate past President, the Treasurer, and certain Standing Committee Chairmen. The work of this Committee proved so effective that the membership approved the establishment of a permanent Executive Committee.

The Committee is to meet at least three times.

Because of their importance and effectiveness the Committee on Membership and the Committee on Branch Operations have been made standing committees of the Institute.

PROCEDURES MODIFIED

Other modifications were suggested because the procedure in the present by-laws for the nomination and election of officers is difficult to follow. These changes were suggested by a special committee appointed by Council.

Improved were the procedures for the election of the Nominating Committee, meetings of the Nominating Committee, the list of nominees for officers, publication of nominations, additional nominations, and the conduct of the officers' ballot.

Also approved for change is a stipulation that the General Secretary shall issue letter ballots on proposed amendments to the by-laws not later than six months after the Annual General Meeting. The time limit had been two months.

SCRUTINEERS' REPORT

Also at the September 29 meeting of the Executive Committee the report of the Committee of Scrutineers was received. Approved by a vote of 35 to 30 was a motion for the improvement of library services. Appropriate action will be taken by officers of the Institute.

EIC

Personals

Michael Shayna, M.E.I.C. (Sask. '51) has recently joined Saskatchewan Clay Products in Estevan, as quality control, research and development engineer. Mr. Shayna was formerly project supervisor with Angus Buther Engineering Ltd., Regina.

William A. Devereaux, M.E.I.C. (Toronto '37), has been appointed Manager of Business Development at Montreal Engineering Company Limited. Mr. Devereaux was formerly General Manager of Yarnall-Waring Company of Canada. Mr. Devereaux will be responsible for business development and general client relations.

W. A. Devereaux
M.E.I.C.

M. Shayna
M.E.I.C.

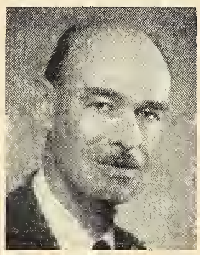
A. R. Harrington, M.E.I.C. (N.S.T.C. '36) has been elected President of Nova Scotia Light and Power Company Limited. Mr. Harrington was formerly the Vice-President and General Manager of the company, and will continue in his post as General Manager.

George Routley has been appointed Montreal representative for Josam Products Limited and Jerren Affiliated Companies Limited. Mr. Routley has had 25 years experience in the plumbing industry.

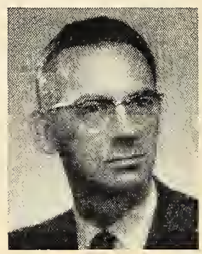
James S. Elder has been appointed Director of Advertising and Promotion for Velan Engineering Ltd. Mr. Elder, an ex-naval engineer brings to his new position several years experience both in the field of power engineering and in advertising.

T. K. Norbury has been appointed head of the newly-created Diamond Drilling Department within the Mining Division of Atlas Copco Canada Ltd.

A. S. Fraser, M.E.I.C. (McGill '22) a Director of the Nova Seotia Light and Power Company Limited since 1955, was elected Vice-President of the company.



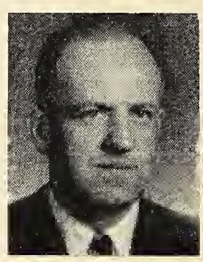
J. T. Howley



J. B. Templeton

J. T. Howley, who since 1956 managed the electrical engineering department in the Windsor office of Giffels & Vallet of Canada Ltd., has been appointed chief engineer with the firm. In this position, Mr. Howley will co-ordinate the efforts of engineering personnel at the firm's Toronto and Ottawa offices. **J. B. Templeton** has been appointed assistant chief engineer. He is also head of the mechanical engineering department in Windsor. **S. G. Wilson** has been named manager of the electrical department to replace Mr. Howley.

S. G. Wilson



M. J. Leddy

M. J. Leddy has been appointed to the newly created position of vice-president, Marketing with Canadian Breweries Limited.

Alan A. Kay, M.E.I.C. has been named operations manager at Deeks-McBride Ltd. Mr. Kay formerly was chief engineer of G. S. Eldridge & Co. Ltd. He has many years experience in heavy industry, consulting and eonstruetion. In his new position he will be responsible for the operation and maintenanee of the Deeks-McBride plants, transport fleet and quality control of products. He will also be responsible for technical services.

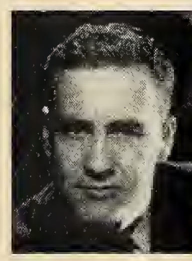
H. W. Argent has been named Technical Officer, Laminating Division, of the Canadian Institute of Timber Construction. Mr. Argent will be located at the Institute's headquarters in Ottawa.

James H. Chipperfield, H. P. Shewman, and **W. T. Wylie** have been appointed to the board of direetors of Manitoba Telephones System.

John M. Hemstock has been appointed concentrator superintendent and **W. S. Hrynewich** assistant concentrator superintendent at Noranda Mines.

D. J. MacDonald has been appointed director of operations, **G. Galibois** has been named manager, outside districts, and **M. Methe** has been appointed chief engineer at Quebec Power Company.

D. Clements



W. A. Woodcock

Denis Clements has been appointed to the Board of Directors of Dexion (Canada) Limited. Mr. Clements joined the company in 1957 and advaneed from Purchasing Manager to full responsibility for plant and production.

W. A. Woodcock has been appointed Chief Engineer at General Motors of Canada Limited. Mr. Woodcock joined General Motors in 1947 and has served as Senior Experimental Engineer, Truck Engineer and, since 1961, as Assistant Chief Engineer.

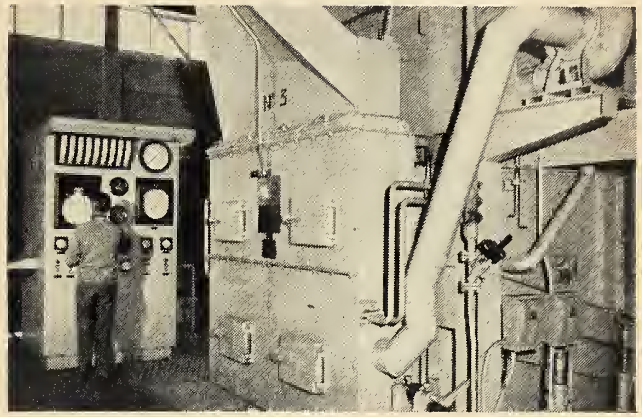
J. W. Dodds has been appointed general manager at Alberta Government Telephones. Mr. Dodds joined the department in 1929. **A. C. Head** has been appointed comptroller with the department. Mr. Head joined the AGT in 1917, and since 1959 has been general traffic manager. **C. L. Keatley** has been appointed general traffic manager. Mr. Keatley has been with the department since 1929, and sinee 1950 has been traffic methods supervisor.

(Continued on page 131)

g·eater efficiency, lower overall costs

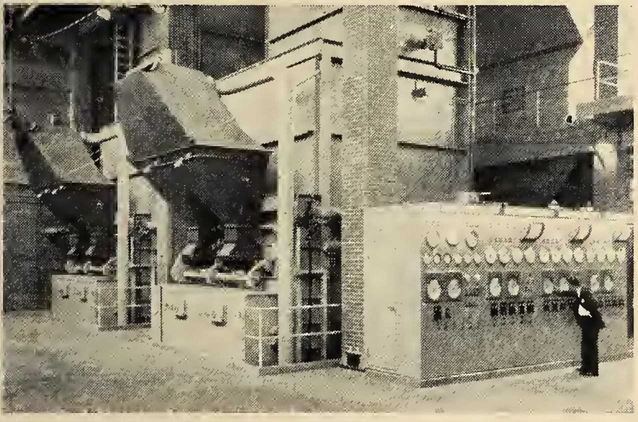
IRON ORE COMPANY OF CANADA

Capacity: 30,000,000 BTU/HR. *Design pressure:* 400 psig. *Inlet temperature:* 250°F. *Outlet temperature:* 380°F. *Fuel:* Oil. *Number of boilers:* 2. *Location:* Carol Lake in Western Labrador. *Engineers & contractors:* Beehtel & Company. *Application:* Supplies heating and hot water requirements for ten buildings spread over several aeres.



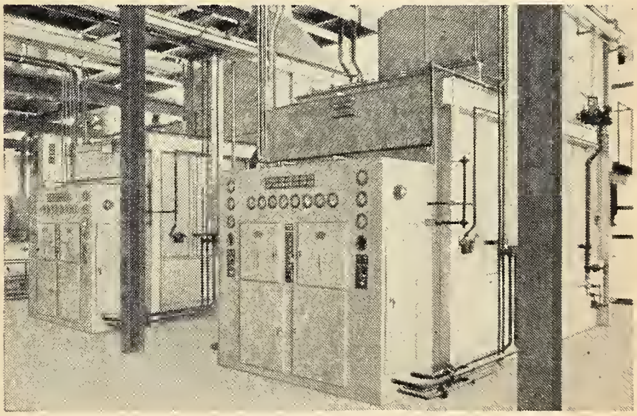
CENTRAL EXPERIMENTAL FARM

Capacity: 30,000,000 BTU/HR. *Design pressure:* 300 psig. *Inlet temperature:* 225°F. *Outlet temperature:* 366°F. *Fuel:* Bituminous eoal or oil. *Number of boilers:* 3. *Location:* Ottawa, Ontario. *Consultants:* Wiggs, Walford, Frost & Lindsay. *Application:* Spaee heating, domestie hot water and steam for air conditioning, autoelaves, sterilizers, pressure eookers, laboratory outlets, etc.



DEPARTMENT OF PUBLIC WORKS

Capacity: 40,000,000 BTU/HR. *Design pressure:* 300 psig. *Inlet temperature:* 220°F. *Outlet temperature:* 350°F. *Fuel:* Bituminous coal. *Number of boilers:* 3. *Location:* Ottawa, Ontario. *Consultants:* J. Klassen & Associates. *Application:* Central heating for ten large office buildings spread over several aeres.



MALTON INTERNATIONAL AIRPORT

Capacity: 27,500,000 BTU/HR. *Design pressure:* 300 psig. *Inlet temperature:* 220°F. *Outlet temperature:* 320°F. *Fuel:* Oil or gas. *Number of boilers:* 2. *Location:* Malton, Ontario. *Consultants:* John B. Parker & Associates. *Application:* Central heating for all buildings in the terminal complex.

Canadian Developments

Canada's first satellite, the Alouette, was hurled into space September 29, at 3 a.m., from Vandenburg Air Force Base near Point Arguello, Calif. The satellite, 34 inches high and 42 inches in diameter, is a small laboratory designed to study the density of electrons in the ionosphere. (See The Engineering Journal, January, 1962.)

The 320-lb. Canadian-built satellite rode a Thor Agena B combination rocket into a nearly circular polar orbit ranging from 597 to 619 miles above the earth. Its speed ranges betwen 15,822 and 15,900 miles an hour.

The new satellite is circling the earth every 105.4 minutes on a path inclined 80.80 degrees from the equator. It is hoped that by means of a radio sounding from above, the satellite will measure the concentration of cosmic rays and other energetic particles, and radiation in space over most of the earth including the polar and auroral zones. In addition to its radio sounding transmitter, and receiver, the Alouette carries two telemetry transmitters to radio its findings to earth on command, and a 50 milliwatt tracking transmitter to permit precise location of the satellite at all times.

In its orbit the Alouette will measure hour-to-hour changes in the ionosphere over almost all of the globe in a period of approximately three months.

The Canadian satellite, part of the Defence Research Board of Canada's Topside Sounder Programme, is under the management and technical direction of NASA's Goddard Space Flight Centre at Greenbelt, Md.

The $33 million Nuclear Power Demonstration (NPD) station near Rolphton, Ont., was officially opened September 25, 1962. Built as a co-operative project by Atomic Energy of Canada Limited, Ontario Hydro, and Canadian General Electric, the 20,000-kilowatt plant was designed to provide information for a full-scale nuclear-electric power program.

The NPD is the world's first nuclear power station to use the combination of natural uranium as a fuel with a reactor moderated and cooled by heavy water.

NPD will not generate electricity at competitive cost as it was designed specifically as a pilot project. It does produce enough power to supply a community the size of Barrie or Pembroke. The station is the culmination of a research program to discover ways and means of using the enormous quantity of heat produced in a nuclear reactor for the production of steam to drive a turbo-generator in a power plant.

The International Atomic Energy Agency recently held a symposium on inelastic scattering of neutrons in solids and liquids. The meeting, held at Chalk River, the research centre having the distinction of having carried out some of the pioneering and most outstanding work on this subject, was attended by scientists from 16 countries.

The subject of the symposium, though highly specialized, had an important bearing on reactor technology. In view of the large number of research reactors in existence or under construction in different parts of the world, there is an increasing interest in this field of research.

Scientists from 13 countries and representing the international organizations Euratom and the Joint Institute of Nuclear Research in Dubna, USSR, presented 65 technical papers. The meeting was co-sponsored by UNESCO.

Other Societies

The Administrative Office of the Column Research Council was transferred to the University of Illinois on September 15, 1962, following the election in May, 1962, of Edwin H. Gaylord, Jr., Professor of Civil Engineering at the University of Illinois, as Chairman of the Council. The new Vice-Chairman is Professor Lynn S. Beedle of Lehigh University. Terms of the offices are three years.

Secretary of the Council is Richard N. Wright, Assistant Professor of Civil Engineering at the University of Illinois. The Council's publications, including its Guide to Design Criteria for Metal Compression Members, are distributed through the administrative office. The new address is 206 Civil Engineering Hall, Urbana, Illinois.

COMING EVENTS

- American Society of Mechanical Engineers. Winter Annual Meeting. New York, Nov. 25-30.
- American Institute of Electrical Engineers. Machine Tools Conference. Detroit, Mich. Nov. 26-28.
- The Iron and Steel Institute. Autumn General Meeting. London, England Nov. 28-29.
- Institute of Radio Engineers. Ultrasonics Engineering Symposium. New York, Nov. 29-30.
- American Institute of Chemical Engineers. 55th Annual Meeting. Chicago, Ill. Dec. 2-5.
- American Institute of Mining, Metallurgical and Petroleum Engineers Inc. 20th Electric Furnace Steel Conference. Cincinnati, Ohio. Dec. 5-7.
- The Institute of Physics and the Physical Society. Meeting on Mass Spectrometry. London, England. December 19.
- Indian Institute of Chemical Engineers. Annual General Meeting. Symposium on Mass Transfer Operations. Calcutta, India. December, 1962.
- The Institute of Physics and Physical Society. Conference on Ultra High Energy Nuclear Physics. London, England. January 7-8, 1963.

Branch News

EDMONTON

R. J. Allman, M.E.I.C.

The Edmonton Branch was host to the Zone "A" Technical Conference held in Edmonton, September 12-14, 1962, in conjunction with the Sixteenth Annual Canadian Soil Mechanics Conference. More than 170 delegates attended this very successful conference held at the University of Alberta. Dr. R. M. Hardy, Soil Engineer, and former Dean of Engineering at the University was general conference chairman.

The first two days of the conference were devoted to Soil Mechanics, and 12 papers were presented which dealt with topics relating to Soils Engineering. In addition to the technical sessions, an evening seminar, and various business sessions were held.

The Zone "A" Technical Conference was conducted on the third day, and six papers were presented on topics relating to pipe lines, electric power, energy interchange and oilfield reserves.

Dr. K. F. Tupper, HON. M.E.I.C., president of Ewbank, Tupper and Associates, and past-president of the Institute, gave a talk entitled, "Wealth" at the stag dinner held on the evening of September 13. Following his talk, the Calgary Branch presented a very humorous skit entitled "Back Page Challenge".

During the Conference, the new wing of the Engineering Building at the University of Alberta was officially opened. The delegates were conducted on a tour of the various engineering laboratories around the campus.

KITCHENER

W. N. Meikle, M.E.I.C.

The Branch opened its fall season September 25 with a social "get acquainted" evening at the picnic grounds of the Conservation Club. Some 60 members and their guests attended. After an appetite-whetting horseshoe competition, dinner was served. Naturally it was that Kitchener district favorite dinner of spare ribs and roasted pigs tails. After dinner two films in a light vein were shown, courtesy Hiram Walker & Sons. Although not technical, these meetings once a year afford an excellent opportunity to meet fellow engineers whom you may not meet in the normal course of business.

LONDON

W. L. Thompson

On September 27, 1962, London members participated in a tour through Canada Cement's plant at Woodstock. London members were the guests of the Woodstock group. A reception followed the tour.

Summer meetings of the Branch included a golf outing and dinner party at the Thames Valley Golf Club on June 26, and a tour of the Timken Roller Bearing Company in St. Thomas on May 15. On April 3, the Branch held a Technical meeting in the Engineering Building at the University of Western Ontario. Dr. A. G. Davenport, of the University, gave an interesting talk entitled, "The Buffeting of Structures by the Wind". His talk included a film covering the destruction of the Tacoma Narrows Suspension Bridge at Tacoma, Wash.

EIC

ONE OF A KIND

OR HUNDREDS

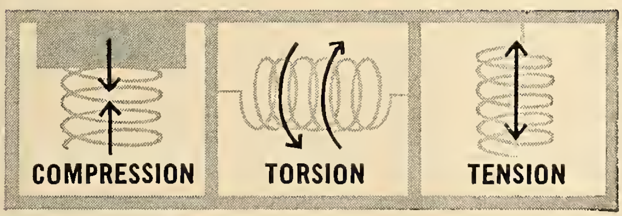
...*hot coiled springs are our business*

When you have a spring problem, in machine design or replacement, you can count on Ontario Steel Products to come up with the answer.

We will coil hot wound springs to your specifications in bar diameters from 3/8″ to 1 7/8″ — inside spring diameters from 3/4″ to 10″ — in free lengths up to 30″ — all to ASTM standards or closer tolerances if required.

You can specify bar size, shape and alloy needs — or discuss your requirements with our engineers.

Springs Shot Peened for longer life.



OSP

Phone or write:

COIL SPRING DIVISION
ONTARIO STEEL PRODUCTS COMPANY LIMITED
OSHAWA, ONTARIO
33 Scott Street, Toronto
407 McGill St., Montreal

Library Notes

*TRANSMISSION ELECTRON MICROSCOPY OF METALS.

The principles, practice, and applications of the transmission technique for thinning metals are presented. Electron scattering, diffraction, and contract, and image formation serve as an introduction to an account of the electron microscope and specimen preparation techniques. Finally, the structure of metals studied by these methods is summarized. Emphasis is on the laboratory techniques of electron microscopy. (Gareth Thomas. New York, Wiley, 1962. 299p., $11.50.)

*CLASSICAL ELECTRODYNAMICS.

A detailed exposition of elecromagnetic theory, the first half of which stresses the basic unity of the subject in both its physical and mathematical aspects. The second half emphasizes the electromagnetic properties of particles, their motions in external fields, the radiation they emit in collisions, and their interactions with one another. The special theory of relativity is developed and used extensively. Discussions of applications to modern physics include magnetohydrodynamics, Cerenkov radiation, relativistic particle motion, synchrotron radiation, and plasma physics. (J. D. Jackson. New York, Wiley, 1962. 641p., $13.00.)

*TECHNICAL REPORT WRITING.

A manual on technical report and letter writing comprises the first half of this book, but perhaps more valuable to the engineering student are the fifty problems which are in the second part. These problems are the data and rough notes which would be compiled in a variety of scientific and technological areas, with suggestions on their organization into a good report, following the advice in the first part. (Howard Schultz and R. G. Webster. New York, David McKay, 1962. 359p., $3.95.)

*ELEMENTARY KINEMATICS OF MECHANISMS.

An introduction to the analysis and design of mechanisms, with emphasis on the fundamentals of motion analysis and mechanism design rather than on descriptive detail. The author discusses kinematic terminology; motion, velocity, and acceleration analysis; linkages; cams; gears; and mechanism trains. (J. R. Zimmerman. New York, Wiley, 1962. 290p., $6.00.)

*GYRODYNAMICS AND ITS ENGINEERING APPLICATIONS.

The first part of this work is concerned with classical dynamics, and presents certain fundamental ideas governing the moving of bodies in three dimensions. The remainder deals with gyroscopic applications, mainly of a mechanical nature. Complete chapters are devoted to stabilizers, the gyro-compass, rate and integrating gyroscopes, gyro-verticals, and gyroscopic suspensions. Inertial navigation is also discussed, as are the whirling of shafts and aircraft gyrodynamics. (R. N. Arnold and L. Maunder. New York, Academic, 1961. 484p., $14.00.)

*ELEMENTS OF INFRARED TECHNOLOGY: GENERATION, TRANSMISSION, AND DETECTION.

The nature of infrared radiation and the performance of infrared components is set forth in a comprehensive manner. Each major aspect is treated both descriptively and mathematically. Discussions are given on the signal fluctuation limit and photon noise in conventional detectors and narrow band quantum counters; the four most important detection mechanisms; the behavior of charged particles in solids in relation to observed optical characteristics of these materials; elemental and imaging infrared detectors and infrared optical materials in use today; and attenuation by the earth's atmosphere. (P. W. Kruse and others. New York, Wiley, 1962. 448p., $10.75.)

*HEATING AND HUMIDIFYING LOAD ANALYSIS.

This work deals primarily with the accurate determination of the design load necessary for maintaining a selected temperature and humidity within a structure. For this purpose it provides a synthesis of the engineering techniques necessary to achieve an effective and economic system design. Climatological, human, and structural factors are considered as well as the applications of thermal engineering. The mathematical techniques for the analysis of heat and mass transmission, in both the steady and unsteady states, are developed and demonstrated. In addition, special problems such as those encountered in solar and panel heating are also treated. Comprehensive coverage of design data in convenient tabular form is included. (F. W. Hutchinson, New York, Ronald, 1962. 494p., $12.50.)

*INTRODUCTION TO STRUCTURAL STABILITY THEORY.

The physical and mathematical foundations of stability analysis of flat elements, the design aspects of plate structures using optimum design analysis and elastic and inelastic stability theory of cylindrical shells are presented in this book, intended for use in a one semester course. Tangent modulus theory and failure mechanism in columns, inelastic buckling theory and failure strength analysis of plates are among the topics discussed. Although the author is a professor of aeronautics, the material is basic for light weight structures in all fields of engineering. (George Gerard. Toronto, McGraw-Hill, 1962. 170p., $7.95.)

*HIGHER SURVEYING; VOL. 2. PRINCIPLES AND PRACTICE OF SURVEYING, 8TH ED.

The methods of conducting topographic and hydrographic surveys are presented. In this essentially rewritten and reorganized edition, chapters on photogrammetry and error analysis have been added, and the chapters on horizontal and vertical control, aerial surveying, astronomical observations, and measurement of flow of water in open channels have been extended. The material on hydrographic surveying and map projections has been revised and condensed, and there is a folder in the back with U.S. Geological Survey symbols and other map information. (C. B. Breed and G. L. Hosmer and rev. by A. J. Bone. New York, Wiley, 1962. 543p., $8.75.)

*DESIGN DATA FOR AERONAUTICS AND ASTRONAUTICS.

This reference work brings together information which has been either scattered throughout the literature or which was previously unpublished. All data are presented in a form suitable for analysis and computation. The scope of the work is suggested by the titles of its subdivisions, which include atmospheric properties, thermodynamic properties of gases, fluid flow properties, aerodynamics, aerothermodynamics, performance, materials, aerothermochemistry, human tolerances, and miscellaneous properties. Correlated data and nondimensional parameters are presented for the sake of conciseness, and graphs are used whenever it is desirable to show trends. (R. B. Morrison. New York, Wiley, 1962. 581p., $18.00.)

(Continued on page 90)

NOTICE TO ADVERTISERS

DEADLINE — Please note that requests for insertions must be submitted in writing not later than the **15th of the preceding month. Cancellations: same as above.**

SITUATIONS VACANT — Classified rate: $6 per column-half-inch per insertion. Display rates: Per insertion — 1/12 page — $100; 1/8 page — $120; 1/6 page — $195; 1/4 page — $215; 1/3 page — $285; 1/2 page — $345.

DATE IN CIRCULATION — 20th of month.

SITUATIONS WANTED — Accepted free of charge from Members of The Engineering Institute of Canada only.

• Library Notes

(Continued from page 84)

*MANUAL OF BRITISH WATER ENGINEERING PRACTICE, 3RD ED.

This manual first appeared in 1950 as the Manual of British Water Supply Practice, and has since been revised and expanded twice. This edition contains two entirely new chapters dealing with land drainage and with industrial water. Extensive additions and rearrangements have been made, especially in those parts of the manual dealing with hydrology, with potable and industrial water treatment, and with aqueducts, distribution, and services. (Oswald Skeated. Cambridge, Heffer, for the Institution of Water Engineers, 1961. 115p., £5.5.0.)

*MAGNETIC AMPLIFIER ANALYSIS.

A general approach to magnetic amplifier circuit analysis is used in this book, based on the equivalent circuit and the block diagram of the servo loop. Simple relationships for calculating amplifier performance from basic core properties are formulated and related to results throughout the book. Both half-wave and full-wave amplifiers are discussed, and transient function generation is covered. (D. L. Lafuze. New York, Wiley, 1962. 252p., $9.75.)

*BIBLIOGRAPHY AND ABSTRACTS ON THERMOSTAT METALS, 1806-1959.

The basis of this bibliography is the 1947 ASME Bibliography on thermostatic bimetals, low-expansion alloys and their applications, which has been brought up to date with many annotations from the Engineering Index. The arrangement is chronological, with a two-page subject index to the 519 abstracts containing headings under various types of applications, forms, iron-nickel and related alloys, testing and calibration, manufacture, and mathematical treatment. Periodic supplements are planned. (American Society For Testing and Philadelphia, Materials, 1961. 56p., $4.00, s.t.p. no. 288.)

*MECHANICS OF ENGINEERING STRUCTURES.

The statics of stresses and strains in curved and straight bar-type structures are presented, with emphasis on design methods of inelastic behavior, dynamic loading, and the use of electronic computation techniques. The authors deal in turn with statically determinant stress results and stress intensities, elastic displacement dealing with the conjugate beam, energy methods, indeterminate beams and collapse, curved structures using the equations of Bresse, slope-deflection, moment distribution, matrix methods, and frequency analysis. It is designed as a text for advanced undergraduate students. (G. L. Rogers and M. L. Causey. New York, Wiley, 1962. 428p., $8.50.)

TRANSISTOR CIRCUIT MANUAL.

This handbook covers typical designs for general applications in industrial commercial and entertainment devices, and includes schematic diagrams, notes on parts values and component parameters, description of circuit operations, the modifications of typical applications necessary to satisfy specific requirements. The circuits covered inelude those for counters, flip-flops, timers, indicators, controls, audio amplifiers, oscillators, radio and TV circuits and AM radio receivers. (Allan Lytel. Indianapolis, Sams, 1961. 255p., $4.95.)

INFORMATION THEORY.

This volume contains the texts of the papers presented at the Symposium on Information Theory held in London in 1960, together with the discussion on them. The thirty-six papers presented were chosen so as to include the latest developments, including the development of adaptive systems, the extension of coding theory, and the development of machinery for simulating thought-like processes, such as pattern recognition, and reading handwriting. The papers are divided into six sections: coding and detection theory; telecommunications systems; human reaction to information; sensory information and biological models; learning mechanisms; classification theory, syntactics and semantics. (Ed. by Colin Cherry. Toronto, Butterworth, 1961. 476p., $16.50.)

MODERN DICTIONARY OF ELECTRONICS.

Definitions of more than 10,000 words and terms are contained in this new dictionary, which also includes over 350 illustrations, and a pronunciation guide. It covers all branches of electronics, including radio, radar, television, recording, etc., and will prove most useful to all those connected with electronics in any way. (Comp. by R. F. Graf. Indianapolis, Sams, 1962. 370p., $6.95.)

INDUSTRIAL BUILDING, VOL. 2.

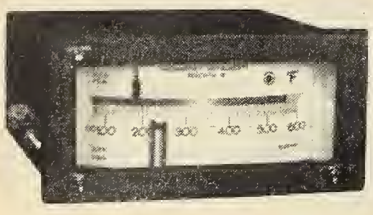
The thirty-six papers in this volume were presented at the second Industrial Building Congress in 1961. The papers covered a variety of topics, including plant location study; evaluating contracts; leaseback financing; design and construction in Mexico and Canada; the effect of building design on employee morale and productivity; lighting; standard costs per square foot; expansion problems; estimating costs; company engineering staff; modernization; use of building models. (New York, Clapp and Poliak, 1962. 203p., mimeog., $10.00.)

FINANCIAL POST SURVEY OF OILS, 1962.

Following the usual practice, the larger part of the Survey is devoted to reviews of Canadian oil and gas companies, giving for each address, company history, properties, wells, balance sheet, etc. Information is also given on dead and dormant companies, and on Canadian production statistics, gas reserves, price range of stocks, and refinery capacity, and the Survey also includes maps of oil and gas areas. (Toronto, Maclean-Hunter, 1962. 216p., $5.00.)

(Continued on page 127)

Industrial Briefs



Multi-element Controller

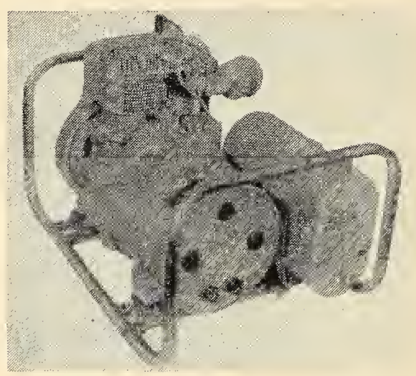
THERMOVOLT LIMITED has announced a new multi-step controller with externally adjustable differential setting. An addition to the fully transistorized electronic controllers used in various industries, the instrument contains two complete control circuits with light beam pick-ups mounted on the same set-point arm. The Model PEC31D could be used as a differential on-off controller with adjustable deadband for motorized or pneumatic control valves, gas or liquid, fueled furnaces, or as a direct pump control on pressure vacuum or refrigeration.

CANADIAN CHAIN AND FORGE CO. LTD. has announced the availability of an electric weld copper-manganese alloy steel chain. This new chain, made from a Canadian developed alloy in which the introduction of copper increases resistance to rust, is being manufactured in ½ inch and ¾ inch sizes. It is claimed to be 40% stronger than the present standard chain. This chain is applicable for sling, boom, marine anchor and conveyor use.

THE 30-AMPERE NPN silicon power transistor line with collector-to-emitter voltage ratings of 300 volts has been announced by the Canadian Westinghouse Company Limited. Continuous power dissipation rating is 250 watts and maximum peak pulse power dissapation rating is 6000 watts. Saturation resistance is less than 0.037 ohms at 20 amperes, and typical thermal impedance is 0.3 degrees C per watt. Maximum junction temperature is 175 degrees C.

A NEW ISSUE of a booklet of steam tables and related data is available from Combustion - Engineering - Superheater Ltd. The booklet, containing a Mollier diagram as well as steam tables from 0.0886 to 3206.2 p.s.i. absolute pressure, includes a skeleton table of supercritical pressure valves. Copies of this booklet are available for 50 cents from the above company at 540 Dominion Square Bldg., Montreal.

THE "ZEUS" 3000 watt A.C. generator with 230 volt three-wire twist-lock and two 115 volt three prong electrical outlets is now available from Electro Sonie Industrial Sales (Toronto) Ltd. The 7 h.p. four-cycle Wisconsin engine has inherent voltage and frequency regulation equipped with rope start and manual choke. Fuel system is equipped with 2¾ gallon tank. Fuel consumption is .25 gallons per kwh. Entire unit weighs only 180 pounds.

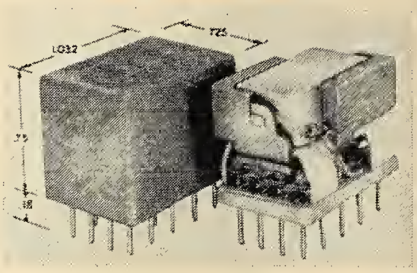


Zeus Generator

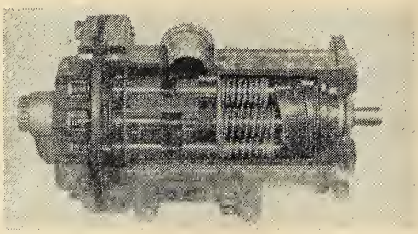
ATLAS COPCO CANADA LTD. has announced the addition of two new models U22 and U19 to its line of two-stage stationary rotary screw compressors. At a discharge pressure of 100 psig, U22 delivers 1040 cfm and U19, 2000. Specific power consumption for the U22 is 25.2 hp/cfm and for the U19, 23.5 hp/cfm. Since they deliver oil-free air, are easy to install and require little space, the compressors are suitable for such applications as instrumentation control and process operations where no oil contamination can be permitted.

AN ALL-PURPOSE silicone rubber adhesive-sealant that requires no added catalyst and adheres to most materials without priming, has been announced by Canadian General Electric Company. The material, known as RTV-102, cures at room temperature to form a durable, resilient silicone rubber. This adhesive could be used for such applications as potting electrical terminal connections, patching and repairing silieone rubber parts, bonding silicone rubber gaskets to metal surfaces, and sealing and encapsulating electronic equipment. This adhesive is capable of withstanding temperatures from −75 degrees F to +300 degrees F for extended periods and up to 500 degrees F for shorter periods.

Microminiature Relay



A MICROMINIATURE four-pole latching relay with hermetically sealed coils has been announced by Potter & Brumfield Division of AMF Canada Ltd., Guelph, Ont. The relay, the TL, its coils encapsulated and sealed in a separate metal enclosure within the case of the relay, cannot contaminate the eontact structure by outgassing. Two Alnico magnets linked by a magnetic yoke provide positive latching action. The TL passes 100Gs shocks with no contact opening. Available in two-coil construction, with a pull-in of 250 milliwatts, the TL can be used for alternate pulsing, or as a differential relay.



Hydraulic Pump

A VARIABLE DISPLACEMENT PUMP having exceptional control versatility, high maximum speed, and pressure capability, is available from the Weatherhead Company of Canada Limited, St. Thomas, Ont. This new pump, an axial piston type, the WO7, incorporates J.I.C. and S.A.E. specifications for industrial and mobile applications. The pump ean be adapted to many applications including automotive, machine tool, material handling and metal fabricating equipment.

Developments

Information contained in this section has been obtained from press releases. Mention of products and services does not imply endorsement by the Institute.

Engineering Education in Canada

The first part of a two-part series on ENGINEERING EDUCATION IN CANADA was published in the September issue of The Engineering Journal.

Plans now call for the publication of part two in the JANUARY issue. Space limitations made it necessary to divide this collection of histories into a series.

Many significant institutions from all parts of Canada will be featured in the January Journal. It is not necessary to point out that the story of Engineering Education in Canada would not be complete without them.

On completion of the series, it is planned to make available a reprint, without advertising, of the complete story.

TECHNICAL PAPERS

FOR THE 1963 ANNUAL GENERAL MEETING

Members are reminded that they are invited to submit papers for presentation at the Annual Meeting in Quebec City, May 22-24, 1963. Deadline for complete manuscripts is January 31, 1963. (Ideal length is equivalent of 4 to 5 Journal pages.)

Abstracts or summaries of 400-500 words should be sent without delay to the appropriate C.T.O. Division Chairman listed below for his consideration in each case:

CIVIL ENGINEERING: Dr. R. M. Hardy, Hon. M.E.I.C., 10214-112th St., Edmonton, Alta.

BRIDGE & STRUCTURAL: A. M. Bain, M.E.I.C., c/o Dominion Bridge Co. Ltd., P.O. Box 280, Montreal, Que.

GEOTECHNICAL: Dr. R. F. Legget, M.E.I.C., National Research Council, Ottawa 2, Ont.

MINING & METALLURGICAL: Dr. R. P. Charbonnier, M.E.I.C., Senior Scientific Officer, Dept. of Mines & Technical Surveys, 562 Booth St., Ottawa 4, Ont.

CHEMICAL ENGINEERING: Dean G. W. Govier, M.E.I.C., Faculty of Engineering, University of Alberta, Edmonton, Alta.

MECHANICAL: Professor A. R. Edis, M.E.I.C., Department of Mechanical Engineering, McGill University, Montreal, Que.

WELDING: (No Chairman appointed as yet—send papers to Mechanical Division.)

THERMAL POWER: D. L. Harris, M.E.I.C., Chief Engineer, Mechanical Services & Thermal Division, Shawinigan Engineering Co. Ltd., 620 Dorchester Blvd. W., Montreal, Que.

HYDRO-ELECTRIC: J. A. Thomas, M.E.I.C., Shawinigan Engineering Co. Ltd., 620 Dorchester Blvd. W., Montreal, Que.

ELECTRICAL: A. J. Girdwood, M.E.I.C., Chief Engineer, Leland Electric Canada Ltd., Guelph, Ont.

COMMUNICATIONS, ELECTRONICS & AUTOMATION: Professor G. S. Glinski, M.E.I.C., Dept. of Electrical Engineering, University of Ottawa, Ottawa, Ont.

ENGINEERING EDUCATION: Professor A. Porter, M.E.I.C., Dept. of Industrial Engineering, University of Toronto, Toronto, Ont.

MANAGEMENT: W. L. Hutchison, M.E.I.C., Moffats Limited, Weston, Ont.

LAKEHEAD TECHNICAL AND PROFESSIONAL ENGINEERING CONFERENCE

Friday, December 7th, 1962

PRINCE ARTHUR HOTEL PORT ARTHUR, ONT.

PROGRAMME

9.00 A.M. REGISTRATION

TECHNICAL SESSIONS:

Buried Cable Techniques
R. M. Cruikshank, M.E.I.C.

Missile and Rocket Metallurgy
Dr. H. P. Tardif

LUNCHEON:

Guest Speaker, F. L. Lawton, President, The Engineering Institute of Canada

TECHNICAL SESSIONS:

Engineering Approach to Traffic and Lakehead Expressway
A. Harvey, M.E.I.C.

5.30 P.M. RECEPTION AND COCKTAILS

DINNER:

Guest Speaker, J. W. Holmes, President, Association of Professional Engineers of Ontario

CALL FOR PAPERS FOR THE FOURTH JOINT AUTOMATIC CONTROL CONFERENCE

THE FOURTH JOINT AUTOMATIC CONTROL CONFERENCE WILL BE HELD AT THE UNIVERSITY OF MINNESOTA IN MINNEAPOLIS ON JUNE 19-21, 1963. PAPERS ON CONTROL THEORY, APPLICATIONS, AND COMPONENTS NOW ARE BEING INVITED.

The sponsoring societies of the JAAC are the American Institute of Chemical Engineers (which has prime responsibility in 1963), the American Institute of Electrical Engineers, the American Society of Mechanical Engineers, the Institute of Radio Engineers, and the Instrument Society of America. Abstracts and papers may be submitted through the member society headquarters with the designation "for 1963 JACC" or to the Program Chairman, Professor Otis L. Updike, Department of Chemical Engineering, University of Virginia, Charlottesville, Va. Early submission is urged. Further details on paper submission will be supplied after abstracts are received. The deadline schedule has been established to permit full preprinting of conference papers.

Papers prepared for the Congress of the International Federation for Automatic Control in Basle may be presented also at the JACC, and will be preprinted in abstract only to conform with IFAC requirements.

—COUNCILLORS—

THEIR RESPONSIBILITY

I have already said something on the subject of "Council—What Is It?" At that time I attempted to outline the role of Council as a collective organ of the Institute, through which the management functions of the Institute are exercised. At this time, I wish to deal with the responsibility of the individual councillor.

If you have been selected by your Branch as its councillor, or one of them where your Branch is entitled to two or more councillors, you have been chosen as the spokesman for your Branch at the deliberations of Council at which policies are developed and administrative action taken. At same time, you obviously must report back to your constituents, your Branch, on Council's policies, actions and plans. Thus you must act as a two-way channel of communications between your Branch and Council.

As a Councillor you have been honoured by your Branch. You are its senior representative in the councils of Canada's leading voluntary, professional, technical and learned society. The effectiveness of Council's deliberations and actions will be a reflection of the way you discharge the obligations you accepted when you became a councillor.

What are your obligations as a Councillor? Some of the more important are:

1. Thoroughly familiarize yourself with what your Branch is doing, its plans for the coming year, new developments of potential value to other Branches. To do this you must attend your Branch Executive meetings regularly. Make sure you are well acquainted with Branch activities.
2. Analyse the papers which come to you from Headquarters. Discuss them with your Branch Executive; ponder the consensus of thinking. Develop your consensus for presentation at the next meeting of Council. If urgent, discuss it with your Vice-president and communicate it to the General Secretary.
3. Make yourself thoroughly familiar with Council decisions and actions, with the philosophy underlying them. Then report back to your Executive Committee and, when desirable, to a Branch meeting.
4. Make yourself thoroughly familiar with the organizational structure of the Institute. Be sure you know the role of the important committees such as the Committee on Technical Operations (CTO), the Committee on Membership, the Committe on Branch Operations (CBO), the Publications Committee, the Finance Committee, etc. Learn how they function.
5. Familiarize yourself with the broader aspects of Institute finances so you can inform your constituents when asked.
6. Know the By-Laws so that you can advise constructively when asked.
7. Know the members of your Branch Executive. Be aware of the probable line-up of Branch Executive members during the next two or three years so that if you see a situation developing that is likely to not be in the best interests of the Institute you can tactfully advise against it.
8. Remember that the "Image" of the Institute is just as bright as the over-all assemblage of its facets. You, Mr. Councillor, occupy a prominent spot in that "Image" of the Institute. Your facet will be so much more brilliant if you play the constructive role for which you were selected.
9. You are a most important member of the management team. Pull your weight!

F. L. Lawton

F. L. Lawton, President.

Discussion

(*Continued from page 68*)

show a typical circuit which employs these devices rather than transistors?

Finally, there is an important application of the Magnetic Inverter which was not mentioned in the paper (probably because it is mainly concerned with multiphase operation) and that is that it can be used in conjunction with a rectifier to "transform" direct current voltages. The rectangular waveshape, of course, makes this very attractive and the method has the added advantage that the output voltage is isolated from the supply.

Authors' Reply

The question of reverse conduction in the ON-transistor of an inverter is raised by Messrs. Maine, Moore and MacMartin. Our subsequent investigations have shown that for the circuit of Fig. 18 in the paper (corrected as indicated below under "Errata"), when a balanced resistive load is used, none of the transistors are required to carry reverse current. With a little effort the reader can satisfy himself that this is so. This result may seem a little surprising. Certainly it is a special case.

Many situations can be visualized in which reverse current is required to flow. For example, if only one phase is loaded with resistance, consideration of Figure 17 indicates that reverse current will flow during portions of each cycle in the 30-degree, 60-degree, 120-degree and 150-degree slaves but not in the master.

Another simple and clear-cut case occurs when a two-phase arrangement, such as the one shown in Fig. 15 of the paper, has its output windings connected in series, differentially, to a resistive load. The load voltage waveform then consists of alternate positive and negative pulses with intervals between them during which the voltage is zero. The relative lengths of a pulse and the interval between pulses depend upon the phase-lock angle. The current waveform will be the same, and it turns out that all load-current pulses in the slave transistors correspond to reverse conduction in these transistors. Although it was not mentioned in the paper one of the disadvantages of loading the slave inverter of Fig. 6 by means of an output winding is that reverse current will flow in the master transistors when the slave only is loaded. This point is discussed in some detail in our earlier paper, Reference 1. A fourth situation in which reverse current is a problem occurs when the load is reactive. In this case the problem can be visualized by considering only a single-phase square-wave inverter with inductive load.

While within limits transistors can handle reverse conduction of the type described, a more effective way of dealing with it is to use diode rectifiers shunted across the collector-emitter terminals so as to bypass this current. In Reference 7 this method was used for handling an induction-motor load. One of the authors earlier suggested the use of such diodes as an aid in spike-clipping,[1] where the problem is not unrelated to this one. There is every reason to believe that this use of diodes will solve any of these reverse-current problems.

That stepped-wave inverters are practical is substantiated by the work of others as well. Subsequent to the presentation of our own paper two papers were presented at the AIEE Summer General Meeting in Denver, Colo., which illustrate the extent of development work in this area.[2,3] While magnetic self-locking has not been exploited in these other schemes synthesis of the sinusoid from a set of rectangular waves is basic to all of them. Considerable attention has been directed not only to the techniques required for generating stepped approximations to sine waves, but also to the development of criteria for optimizing these approximations.

In a single-phase inverter the division of transistor currents into load and magnetizing components is a division of convenience which is physically meaningful. As in an ordinary transformer under load the magnetizing current is not directly measureable. Thus, using Fig. 3 of the paper, one can reason that when the collector voltage of transistor T1 is at the level XY and that of transistor T2 at level X'Y' the current carried by T2 is given by the horizontal distance from the voltage axis to X'. At this same instant the load current referred to the primary is given by the horizontal distance from the voltage axis to Y'. Thus the current X'Y' must account, in part, for the magnetic state of the core. Similarly the current XY (or really the current given by the horizontal distance from the voltage axis to Y) must account in part for the magnetizing current. In fact then XY and X'Y' together must account for the magnetic state of the core. Contrary to the statement in the original printing of the paper (and as noted in the "Errata" below) the magnetizing current is the sum of, not the difference between, XY and X'Y'. Specifically Messrs. Moore and MacMartin raise the question of how point L in Fig. 3(a) can be located. Our description falls short of a quantitative theory which can be used to predict the location of all points on the switching locus. A few of the more obvious ones such as the points A and K defined by the load-line, point C and point E can readily be predicted. Our explanation does

however relate the observed behaviour of the transistors during switching to the magnetic state of the core. Formidable analytical difficulties preclude a complete analytical treatment.

Professor Card, Mr. Moore and Mr. MacMartin have commented on the use of silicon controlled rectifiers as the switching elements in inverters. Most SCR-inverters known to the authors are not within the class discussed in the paper. That is, their operating frequencies and, if polyphase, their phase-lock angles are not dependent upon the characteristics of the inverter transformers. Because of the nature of the SCR it cannot be used as a direct replacement for the transistor in any of the circuits shown in the paper. As with a thyratron, the anode-cathode voltage of the SCR must be made negative briefly in order to shut it off and enable the control electrode (gate) to regain control. Most SCR inverters use a timing oscillator or trigger circuit to drive the gate electrodes and are characterized by an anode-to-anode capacitor and an inductor in series with the d-c supply lead which together make satisfactory commutation possible.[4] One unusual SCR inverter,[5] in which the frequency does depend upon saturation in the transformer core, has been presented subsequent to the presentation of our own paper but prior to the time at which this note is being written. This inverter was developed by a group at Duke University. In it a double-core arrangement is used in which windings similar to those designated N_1 and N_L in Fig. 1 of our paper are wound so that their turns link both cores of the double-core. Auxiliary windings which, together with capacitors, control the switching in the inverter are placed on only one of the two cores and become operative only when the main core saturates. For further circuit details the reference should be consulted.

Professor Card's point relating to the increased power rating available when SCR's are used, a point to which reference was made in the introductory portion of our paper, is well taken. Since our paper was written further evidence of the sort of ratings which have already been obtained in this way has come to our attention.[6,7] These go as high as 50 kva and cover a wide range of applications including high-frequency lighting, ultrasonic generators, and variable-speed synchronous motor drives.

We have not experimented with induction motor loads on polyphase inverters of the self-locking class and hence cannot comment in detail upon Professor Card's suggestion that the normally-unstable leading phase relationship might be stabilized with such a load. We have some doubt about the likelihood of stability under these circumstances, but certainly the prospect is interesting.

Finally, regarding the relative merits of sinsuoidal and square-wave power supplies, we believe that the choice must be determined by the application. Often of course in commercial work one must meet a specification relating to harmonic content. Probably the main incentive in the development of stepped-wave inverters has been the need to meet such a specification in an economic way. There is probably some justification for examining the reasons why some of these specifications are written as they are. For example a decision to accept no more than five percent total harmonic distortion may be quite arbitrary and taken with little thought to the real needs of the situation. Nevertheless, the use of sinusoidal waveforms should not be cast aside too lightly. A host of factors are involved. Analytical simplicity should not be ignored. Predictable and minimal voltage stresses during transients of all sorts are factors which favour sinusoids. Radio interference will be reduced if harmonic content is minimized and steep wavefronts avoided. A good discussion of the effect of square-wave drive on a particular load, a two-phase induction motor, is given in Professor Card's paper cited as Reference 7 in our paper. Square-wave output is particularly advantageous of course when the object is to transform from one d-c voltage level to another, ordinarily higher, level. Rectification of the a-c output is required in this case, and square-wave input to the rectifier reduces the output filtering requirements almost to the point where they are nonexistent. This is the application cited by Mr. Moore and Mr. MacMartin in their discussion.

1. Differential Magnetic Multivibrators. C. H. R. Campling, AIEE Conference Paper 57-769, Summer General Meeting, June, 1957, 11 pp.
2. Methods for Optimizing the Waveform of Stepped-Wave Static Inverters. P. D. Corey, AIEE Conference Paper 62-1147, Summer General Meeting, June, 1962, 7 pp.
3. Static Power Inverter Utilizing Digital Techniques and Harmonic Cancellation. D. L. Anderson, A. E. Willis, C. E. Winkler. AIEE Conference Paper 62-1148, Summer General Meeting, June, 1962, 15 pp.
4. Controlled Rectifier Manual, First Edition. Canadian General Electric Company, Ltd., Toronto. pp. 126-143.
5. A Self-Oscillating Inverter Using a Saturable Two-Core Transformer to Turn Off Silicon Controlled Rectifiers. E. T. Moore, T. G. Wilson, R. W. Sterling. AIEE Transactions Paper, 62-1029,
(Continued on page 114)

• Discussion

(Continued from page 113)

Summer General Meeting, June, 1962, 11 pp.

6. DC and AC Power Conversion by Semiconductor Converters. Edward J. Duckett. IRE Transactions on Industrial Electronics, vol. IE-9, No. 1, May, 1962, pp. 48-55.
7. A 50-KVA Adjustable-Frequency 24-Phase Controlled Rectifier Inverter. C. W. Flairty. Ibid. pp. 56-60.

Errata

(Page and figure numbers refer to the original printing of the paper.)

(1) page 2, column 2, line 26—"difference between" should read "sum of".

(2) Fig. 18—some of the connections in B-phase and C-phase are shown incorrectly. Change as follows:
B-phase: Reverse the connections to the master, the 60° slave and the 90° slave.
C-phase: Reverse the connections to the 90° slave and the 120° slave.

SELECTION OF DYKE FREEBOARD AND SPILLWAY CAPACITY FOR GRAND RAPIDS GENERATING STATION

I. W. McCaig,
Director

F. H. Jonker,
Hydraulic Engineer

W. Hamilton,
Engineer,

H. G. Acres & Company Limited,
Consulting Engineers, Niagara Falls, Ont.

The Engineering Journal,
November, 1962
page 46.

Discussion by :
J. R. Rettie,
Director of Engineering,
Manitoba Hydro

Selection of dike freeboard and spillway capacity on a project of this nature is far from an exact science and requires sound engineering judgement in selection of values for parameters used in calculations. Space limitations no doubt account for omission of information in support of data and assumptions provided in the paper, much of which was included in detailed memoranda provided by the consultants to Manitoba Hydro.

Information pertinent to the subject but not contained in the paper includes: reasons for selection of a design windstorm having an estimated return period of 5,000 years compared with 1,000 years or 10,000 years, values used for wind velocities for storms of different durations, the probabilities of experiencing extreme winds from the most critical direction (which was assumed), the method used by Hudson in calculating wave run-up, the possibility of using drawdown to reduce setup and wave runup to combat the 5,000 year storm, the possibility of using wave dissipating structures in the immediate forebay area and discussion of spillway dimensions and powerhouse discharge capacity assumptions.

A more complete description of interpretation of Fig. 8 would be desirable. Definition of the units to be applied for the various elements in using the set up formula is required. The description of factor D is omitted entirely and I assume it represents the average depth of the forebay in feet. The value of C is given as 3.84 x 10^6, and probably should be 3.84 x 10^{-6}. Another minor correction is required for Fig. 6 the vertical scale of which should read "Annual Charges in Hundreds of Thousands of Dollars".

The foregoing comments are directed entirely to the text of the paper under discussion. We at Manitoba Hydro have every confidence in the approach used by our consultants in determining dike freeboard and spillway capacity.

Discussion by :
Dr. A. Brebner
Queen's University

It is encouraging and heartening to see the authors of this paper putting into practice much of the work of the last decade on set-up and wave-run-up.

The problem of set-up due to wind stress is an especially difficult one at any time due to the paucity of field information with which to back up theoretical or laboratory investigations and the configuration at the junction of Cedar and Cross Lakes complicates the issue even more. The step analysis of the problem is undoubtedly the best way of arriving at the most probable result. However, due to the startling lack of information given in the paper regarding water-depths and wind speeds (and their distribution) the writer was unable to even roughly verify their calculations using approximate methods such as the Zuider Zee formula or the Beach Erosion Board Technical Report No. 4 (1961 edition) method. The writer would also question the use of such an exact value of C in formula 1.

In view of the conflicting values of wind-stress against wind velocity measurements available such a degree of accuracy in C is questionable since the relationship for high velocities are probably based on results from one location, namely hurricanes on Lake Okeechobee.

Further, in arriving at the values of set-up on the dikes did the authors consider the seiche effect caused by the difference in barometric pressure between the two ends of the reservoir?

With regard to the ratio of wind-speed over water to wind-speed over land the ratios of Hunt have been sensibly confirmed by Lemire for land stations a fair distance from the water but if the meterological stations are near the water the wind blowing over the water towards the land is not much affected so that the ratio suggested may be too high.

The wave-height figures of the authors seem quite realistic. The writer has calculated a significant wave-height of around seven feet at a wind-speed of 50 m.p.h. Since wave refraction is most marked in the triangular fore-bay the authors' run-up value seems a very good design figure.

In conclusion the writer would like to congratulate the authors on their treatment of the problem and would only criticize the lack of factual information on which they base their design.

Authors' Reply

The authors understand the concern of Messrs. Rettie and Brebner that much pertinent data and material were not included in the paper. It is unfortunate that in writing this paper, space only allowed mention of the highlights of the investigation. Inclusion of additional material was considered, but abandoned when it was found to unduly lengthen the paper and to cloud the main argument.

A misprint in the value for the constant C is regretted. The correct value should be 3.84×10^{-6}. Dr. Brebner questions the reality of evaluating the constant C to three significant figures. This value was derived by plotting the shear stress of the wind on water against the wind velocity. The plotted values were obtained from data published in various technical papers, and included both laboratory and field measurements. The line of best fit through these points was then determined, and the constant in this equation was reduced to the nearest round figure. By inserting this value in the equation for the wind setup the value of the constant C equal to 3.84×10^{-6} was obtained.

The influence of barometric pressures in setting up a seiche in the reservoir was considered. The value of this seiche was found to be less than that due to wind setup. It would not be cumulative on top of setup as, due to the earth's rotation, the wind's direction is along rather than at right angles to lines of equal atmospheric pressure.

A realistic evaluation of the ratio of wind speed over water to wind speed over land, was the most difficult and also the most important part of the setup investigation. A number of meteorological authorities were consulted, and the values adopted were considered to be the most realistic for conditions applicable at Grand Rapids.

Figure 8, which indicates the economic combination of spillway capacity and freeboard for various combined frequencies of winds and floods is important in indicating the relative economy of adding additional spillway capacity versus increasing the height of dykes for flood storage.

The intersections of the broken sloping lines of this figure with the full lines A, B, C and D indicate, for various combined frequencies of windstorms and floods, the total cost of spillway and freeboard. By examining, for instance, the case of a combined frequency of one in one thousand years, it can be seen that the cost of this degree of protection by providing four spillway gates together with setup freeboard of 4.3 feet is \$5.9 million. The same protection could be provided with one less gate if the freeboard were increased to six feet, but the total cost of dikes and freeboard would be increased to \$6.5 million.

Similar trends are evident with other combined frequencies of winds and floods, thereby indicating that an increased height of dike for the provision of flood storage alone is less economic than providing sufficient spillway capacity such that flood storage is kept within the range allowed for extreme setup.

Figure 6, Economy of Protection, was originally intended to be illustrative only. If the vertical scale reads annual charges in hundreds of thousands of dollars, it would correspond closely with the values of cost of spillway and freeboard given in figures 8 and 9.

(Continued on page 116)

Discussion

(Continued from page 115)

FOUNDATION FAILURE OF A SILO ON VARVED CLAY

W. J. Eden, M.E.I.C.
M. Bozozuk, M.E.I.C.
Research Officers, Soil Mechanics Section,
Division of Building Research,
National Research Council, Ottawa

The Engineering Journal, September, 1962, page 54

Discussion by Dr. G. G. Myerhof,

Head,
Department of Civil Engineering,
Nova Scotia Technical College

The paper represents an important case record and is probably the first publication of a large-scale foundation failure on varved clay. In spite of the sensitive nature and relatively low strain at failure of this material, excellent agreement between the theoretical and observed failure loads has been obtained when an allowance for the adhesion between the foundation concrete and soil is made. Although the shearing strength of varved clays varies with the inclination of the failure plane in relation to the direction of the varves, the field vane test results give better agreement than the undrained compression tests which may be affected by some sample disturbance. Nevertheless, the maximum laboratory strength would also appear to be in reasonable agreement with the estimates, if an allowance for the variation of shearing strength with inclination between the varves and the probable sliding surface had been made.

Discussion by

D. L. Townsend, M.E.I.C.
Queen's University

As an instructor in soil mechanics, it is particularly gratifying to read of cases such as this where the theoretical calculations so closely agree with the actual results experienced in the field. In many cases the design factor of safety is so chosen that there is often little chance to verify theories with any precision and field measurement. The natural soil conditions are so varied that one wonders if the precise assumptions of the classroom are ever approximated in the field.

Such a record is of added personal interest in view of the varved clay which was encountered at the site, since there are few case records with this type of soil.

Investigations conducted at Queen's University by Gay[1] under this discussor's supervision have indicated that during shearing there is a definite movement of water from one layer in a varved soil to the other. For these tests, artificial varved samples were prepared from a slurry using two different soils which had the properties given in Table I. The strength tests were conducted at 0.4% strain/minute and the moisture contents measured after failure with the appropriate layer thickness are given in Table 2. From these results it can be seen that a definte moisture movement does take place between the layers.

Hughes[2] used small needles inserted into the individual layers of similar artificial varved soils to experimentally verify that the moisture movement was caused by a substantial difference in pore pressure between the layers. In addition, the mobilized angle of shearing resistance in terms of effective stresses, ϕ', varied with the amount of strain and the relative position within the layer. Typical results for one of the soils when tested at 0.4% strain/minute are given in Table 3.

Additional tests were run where 90% of the ultimate total deviator stress was applied within five minutes, and the needles were used to observe the dissipation or increase in the pore pressure in each layer and the time taken to reach equilibrium conditions. For an artificial sample with a drainage path of 1.5 inches, the time to reach equilibrium was 90 minutes, and a single test on a natural varved soil which had a 0.3 inch drainage path took up to 200 minutes to reach an equilibrium pore pressure condition.

In addition to these experimental results, Kenney[3] has suggested that the ratio between the coefficients of volume compressibility and expansibility of the layers in the varved soil may be critical for cases shortly after construction.

TABLE 1
Soil Properties of Artificial Samples

	w_L	w_P	C_C	C_R	c_v cm²/sec	c_r cm²/sec	k cm/sec
Soil "L".........	36	18	0.22	0.02	2.0×10^{-3}	8.4×10^{-3}	4×10^{-8}
Soil "D".........	40	18	0.21	—	4.6×10^{-3}	—	$.7 \times 10^{-8}$

TABLE 2
Final Moisture Contents, Artificial Samples
at Cell Pressure 1.4 kg/cm²

	Assumed Initial m.c.	Layer Thickness (cms)			
		2.67	2.00	1.00	0.50
Soil "L"....................	21.0	21.4	21.9	22.7	23.9
Soil "D"....................	24.8	24.2	23.8	23.5	22.1

TABLE 3
Variation in ϕ'_{mo} with Position in Layer, Soil "L"

Distance from Interface	Percent Strain						Maximum Test Value
	1.5	2.0	4.2	5.8	6.7	15	
0.2 inch.........	19°	21°		26°		28°	33.5°
1.5 inch.........	15°		18°		22°	26°	33.5°

These preliminary results have been mentioned in some detail since they have not been presented before. Their purpose is not to divert attention from the value of the paper but to indicate that the rate of strain may be of more than considerable importance for the shear strength testing of varved soils.

A different rate of testing between two tests might allow more moisture to migrate from one layer to the other during the same interval. Hence the mobilized effective stresses could change, and this would be reflected in different total stress results between the field vane and the undrained triaxial result. Certainly some of the discrepancy will be due to sampling, (which may be manifested by distortion of the layers) but it is felt that the sampling should not produce a 40% discrepancy between the averages of the two test methods.

It would be appreciated if the authors of the paper could supply additional information on such items as the rates of strain used in both the laboratory and field test programmes. As an indirect measure of possible moisture movement, was the buldging of the triaxial samples confined to only one soil layer, or was there a uniform barreling throughout the sample?

Due to the thinness of the individual layers within the varves in the upper strata, it is unlikely that the properties of the individual soils in each layer have been determined, but it would also be interesting to know the bulk soil results for permeability, coefficients of consolidation and rebound, and compression indices for the soil.

References

1. Gay, G. C. W. (1961) "Preparation and Shear Strength Characteristics of Some Artificial Layered Soils", M.Sc. Thesis, Queen's University.
2. Hughes, G. T. (1962), "Pore Pressure in Varved Clays", Ph.D. Thesis, Queen's University.
3. Kenney, T. C. (1961), Discussion on Varved Clays, 14th Canadian Soil Mechanics Conference, Niagara Falls, pp. 242-251, National Research Council of Canada, ACSSM Tech. Memo 60, June 1961.

Discussion by V. Milligan, M.E.I.C.,

Partner, H. Q. Golder & Associates Ltd.

As good things are invariably simple, so this paper, which describes the failure of a silo on soft varved clay, is simple and well presented. The data has been carefully assembled by the authors and various mechanisms of foundation shear failure examined.

If one assumes that the annular concrete foundation ring and the weight of silage resting on natural ground within the structure act in concert, and the fact that the silage juices which were observed to seep under the foundation ring and rise to the ground surface did not reduce clay adhesion, then the bearing capacity formulae proposed by Skempton[1] and Meyerhof[2] would adequately explain the failure. These are uncertainties neglected by the authors in their analyses which might be questioned.

The authors have further illustrated the value of in situ vane testing in this stratified deposit. Similar correlation of the vane shear strength with the undrained shear strength as measured in the laboratory has been noted in the study of an embankment failure on soft varved clay. This failure and some data relating to it are illustrated in Figures 1 to 3. It may be noted that normal methods of analysis for the failure using the undrained shear strength or $\phi = 0$ hypothesis, as one would apply for an earth structure on a homogeneous clay deposit, proved to be

(Continued on page 118)

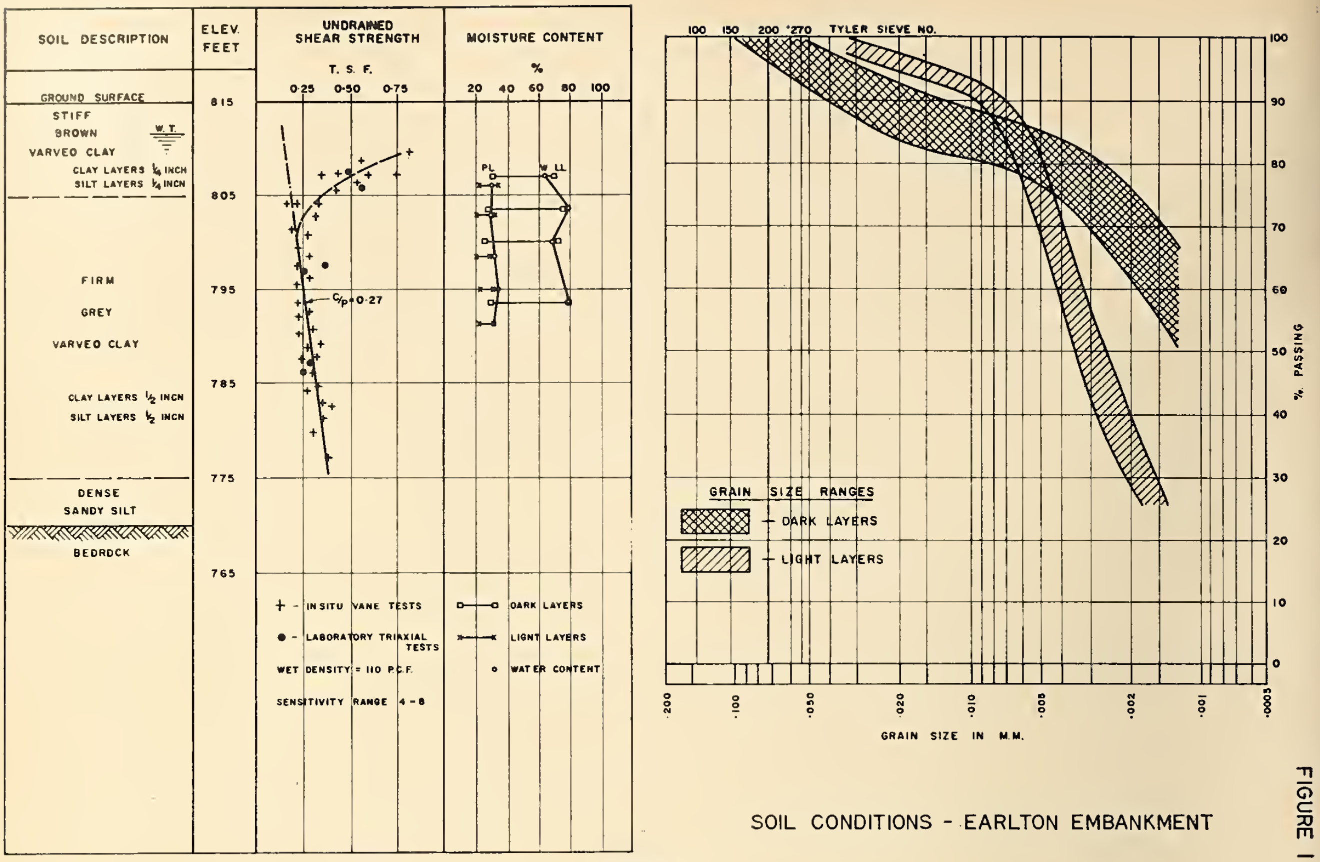


Figure 1.

sound for this stratified deposit. However, there is a danger in the extrapolation of this experience to suggest that the sole use of vane shear tests would be valid for all varved clays. Where the individual layers are thin, of comparable thickness and of similar degree of structure (generally liquidity indices for both layers close to 1) then experience has indicated that in situ vane shear tests give good agreement with undrained compression tests on thin wall tube samples. However, where the layers are thick and of dissimilar degree of structure, no agreement may be found. This point has yet to be studied.

It should also be pointed out that the liquidity indices given by the authors for the varved deposit, namely between 1.3 and 2.0, seem very high in comparison with available data[3] for similar stratified deposits in Ontario. It is possible that some of the tests as detailed in the paper, were carried out on bulk samples rather than on individual layers of the samples and thus do not give a true indication of the properties of the deposit.

References

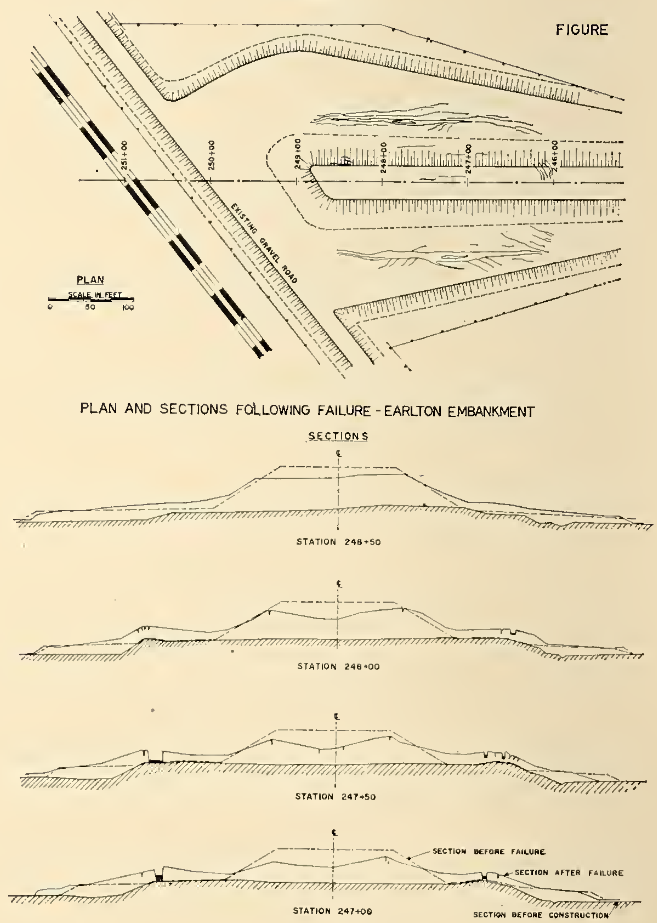
1. Skempton, A. W., 1942. **"An Investigation of the Bearing Capacity of a Soft Clay Soil".** Journal Inst. of Civil Engineers. Paper No. 5305, Vol. 18, 321.
2. Meyerhof, G. G., 1951. **"The Ultimate Bearing Capacity of Foundations".** Geotechnique, Vol. 2, pp. 301-322.
3. Milligan, V., Soderman, L. G., and Rutka, A., 1961. **"Experience with Canadian Varved Clays".** ASCE Annual Convention, New York, October 20, 1961. (In Press).

Author's Reply

The authors appreciate the comments of Dr. Meyerhof, Professor Townsend and Mr. Milligan concerning the behaviour of varved clay under shear stresses. Although the excellent agreement achieved in this case may have been fortuitous, the authors be-

(Continued on page 120)

Figure 2.



Where there's **OIL,** you need **NEOPRENE**

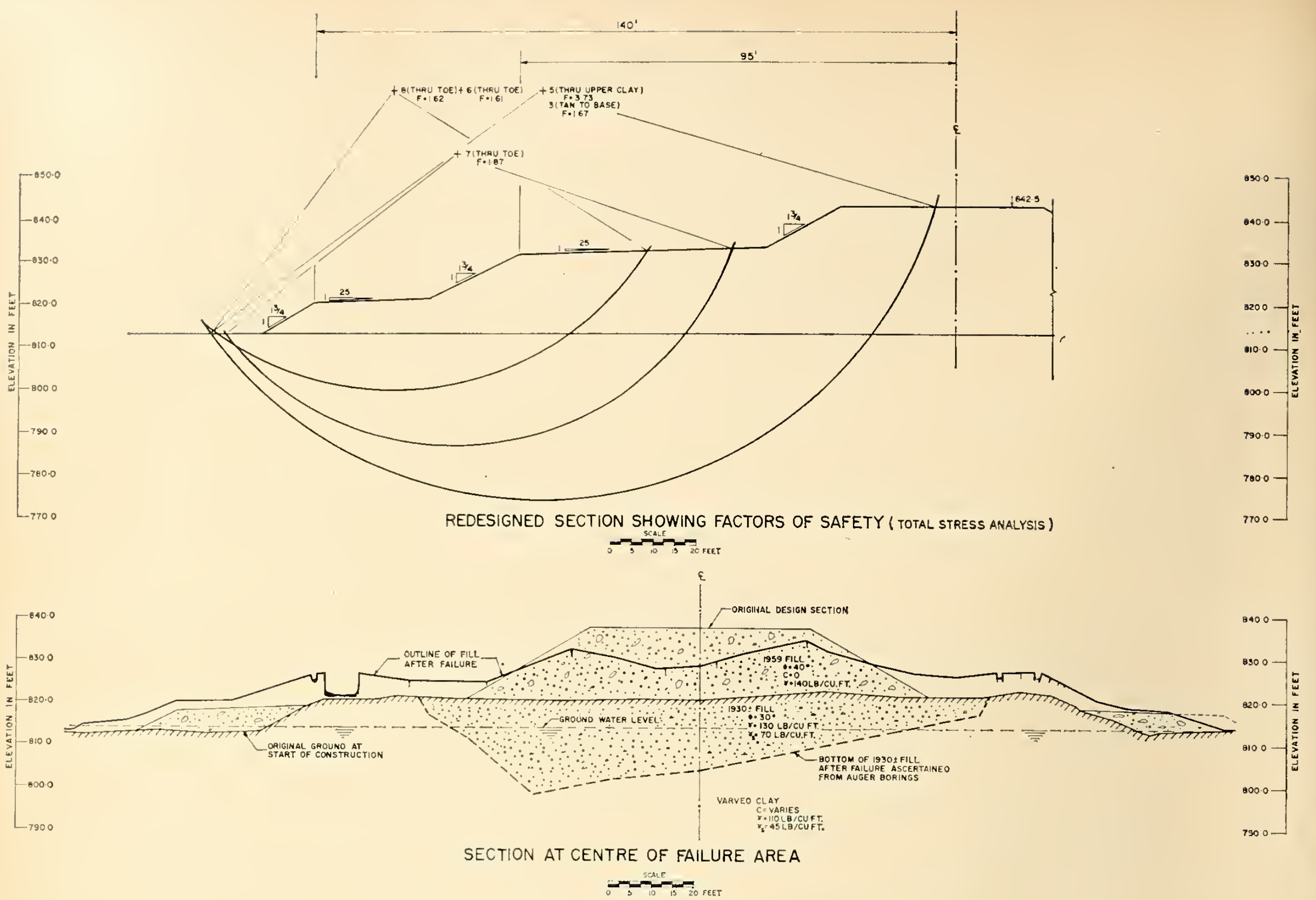
Oil softens and deteriorates most general purpose rubbers—but not time-proved Neoprene. Prolonged contact with any of a wide variety of oils has little or no effect on Neoprene—or on its unique balance of properties.

Where there's oil, there's often heat. Neoprene won't soften or melt. There's also the hazard of fire. Neoprene provides a safety factor; it won't support combustion. In addition, Neoprene resists abrasion, chemicals, ozone, aging, strong sunlight and weather.

It will pay you to check your requirements for a rubber product or part against the properties of Neoprene. The long-term, all-around dependability of Neoprene can net substantial savings.

For example: Neoprene-covered tank wagon hoses are twisted and flexed . . . dragged across rough surfaces . . . exposed to oil, grease, and extremes of weather . . . for years and years . . . without loss of toughness or resiliency. In some cases, they have even outlasted the **trucks.** For technical data on Neoprene-covered hose, write Du Pont of Canada Limited, Elastomers, 85 Eglinton Ave., East, Toronto 12, Ontario.

NEOPRENE
ANOTHER RELIABLE
DU PONT
CANADA
ELASTOMER



RE-DESIGNED SECTION - EARLTON EMBANKMENT

Figure 3.

lieve it demonstrates that the $\phi = 0$ analysis can be applied to the rapid loading of highly plastic varved clays where the bulk properties resemble those of more uniform clays.

In reply to the specific questions raised by Prof. Townsend, the rate of strain used in the laboratory undrained strength determinations was 1% per minute. The rate of strain used with the field vane tests cannot be definitely stated. Although the instrument head is rotated at 6° per minute during the appiication of stress, the long slender torque rods store energy which is released suddenly when the soil fails. Hence the field vane test is more nearly a constant rate of stress application than a constant rate of strain test.

In the undrained laboratory strength tests, the strain at failure varied considerably, presumably being related to the amount of disturbance which the sample had suffered. A number of samples failed at less than 1% while two specimens had failure strains of greater than 10%. The average failure strain for all the tests was 4.3%. Generally, the samples from the upper clay horizon failed on one or more well-defined shear planes without noticeable bulging. In the lower clay with the better defined varves, failure took place as Prof. Townsend suggests by bulging in the light layers which caused vertical cracks to develop in the more brittle dark layers due to the spreading action.

From the consolidation tests on bulk samples, the following results were obtained.

- Coefficient of permeability — approximately 1 x 10^{-5} cm/sec
- Coefficient of Consolidation — 0.003 to 0.006 cm^2/min
- Coefficient of Rebound — 0.02 to 0.06 cm^2/min
- Compression Index — 1.5 to 2.0, possibly greater than 2.0 for some tests.

It is believed that sample disturbance was a serious factor in the undrained laboratory strength test because of the high sensitivity of the clay. The sampling was conducted with a thin-walled fixed piston sampler with an area ratio of about 10%. The samplers were pushed in with a single thrust with care being taken to prevent over-driving. They were sealed on the site and transported by a light truck from New Liskeard to Ottawa. In the light of recent investigations in Sweden,[1] the transportation and subsequent storage probably contributed considerably to the sample disturbance and to the decreased strength of the laboratory test results.

Mr. Milligan raises the point of uncertainties in the application of bearing capacity theory to a case such as this silo. There are indeed many uncertainties in this case. For example, the foundation ring probably supported a very large portion of the load due to the tendency of the silage to adhere to the walls of the silo; there was quite likely some eccentricity in the loading and here there was considerabl variation in the clay since the vane tests varied from 500 p.s.f. to 170 p.s.f. to a depth of 20 ft. In spite of the many uncertainties, the bearing capacity theory has been reasonably successful as indicated by the studies of several case records by Skempton.[2] Mr. Milligan presents a case record of loading on varved clay where the $\phi = 0$ analysis was successful for an embankment load.

The point raised by Mr. Milligan concerning varved clays in which the layers had very dissimilar properties is well taken. It should be emphasized in this case that the failure was probably confined to the upper, more uniform clay and may not be indicative of the behaviour of the lower, more distinctly varved clay.

The liquidity indices given in Fig. 3 are for bulk properties. For the lower three samples it was possible to conduct tests on separate layers and the results of these are tabled below:

	Aver W.C.	*L.L.*	*P.L.*	*P.I.*	*L.I.*	*% Clay*
118 - 7 Bulk	65.2	51.1	22.8	28.3	1.8	73
118 - 7 Light layers	43.6	36.7	20.9	15.8	1.4	54
118 - 7 Dark layers	73.4	65.2	25.6	39.6	1.2	93
118 - 8 Bulk	51.6	35.8	20.6	15.2	2.0	50
118 - 8 Light layers	32.4	28.9	20.4	8.5	1.4	33
118 - 8 Dark layers	72.5	60.4	25.8	34.6	1.35	87
118 - 9 Bulk	50.3	37.3	20.5	16.8	1.8	50
118 - 9 Light layers	31.7	28.9	22.0	6.9	1.4	32
118 - 9 Dark layers	75.6	60.0	25.2	34.8	1.4	86

It can be seen that when tests are conducted on separated layers the liquidity indices of the separate layers are of the same order. The table further indicates that tests on bulk samples of varved clay can be somewhat misleading.

References

1. **Standard Piston Sampling.** A Report by the Swedish Committee on Piston Sampling. Proceedings, No. 19, Swedish Geotechnical Institute, Stockholm, 1961.
2. **The Bearing Capacity of Clays** by A. W. Skempton. Proceedings, Building Research Congress, London, 1951. pp. 180-189.

(Continued from page 90)

FM MULTIPLEXING FOR STEREO.

In 1961 the FCC in the United States announced its stereo broadcasting standards. This volume is for those interested in adapting receivers to receive FM stereo broadcasting. It is a guide to the principles of FM stereo multiplexing, the theory and operation of the various receiver circuits and the alignment and servicing of units. (Leonard Feldman. Indianapolis, Sams, 1962. 160p., $2.50.)

SYMPOSIUM ON ELECTRICAL CONDUCTIVITY IN ORGANIC SOLIDS.

This symposium, held in 1960, was sponsored by departments of the U.S. Army, Navy and Air Force. The 28 papers presented covered such topics as: charge-transport processes in organic materials; photoelectric properties of semiconducting organic dyes; aromatic hydrocarbons; anthracene molecular-orbital theory and crystals; dispersion forces in molecular crystals; ionic organic photoconductors; chemical aspects of semiconductive compounds; semiconductive properties of molecular complexes. (Ed. by H. Kallmann and M. Silver. New York, Wiley/Interscience, 1961. 398p., $12.50.)

°PROCEEDINGS OF THE WESTERN CONFERENCES ON PRESTRESSED CONCRETE BUILDINGS.

This volume contains papers presented at the two Western Conferences on Prestressed Concrete Buildings held in November, 1960 at Los Angeles and San Francisco, California. The papers and the panel discussions place particular emphasis on recent developments in the industry and on solutions to problems worked out by architects and engineers with wide experience in prestressed concrete applications. They discuss structural and architectural integration and coordination in prestressed concrete design; types and uses of precast prestressed members; design of joints and connections in precast and prestressed concrete structures; construction, inspection, and maintenance of prestressed concrete; economics and applications of precast prestressed concrete. (Ed. by T. Y. Lin and J. W. Kelly. New York, Gordon and Breach, 1962. 322p., $12.50.)

DICTIONNAIRE CANADIEN—THE CANADIAN DICTIONARY.

The first dictionary designed specifically for translation and understanding between Canada's two official languages, the volume not only contains all the words found in European dictionaries of comparable size, but also includes words, phrases, and concepts which are uniquely Canadian. The peculiarly Canadian words are clearly indicated, and it is also noted when Canadian usage differs from European. It establishes a standard Canadian spelling for both French and English.

The dictionary was compiled at the Lexicographic Research Centre of the University of Montreal. It will prove to be an essential reference volume in all Canadian offices, libraries and homes. (Ed.-in-chief Jean-Paul Vinay. Toronto. McClelland and Stewart, 1962. 862p., $5.95.)

(Continued on page 128)

• Library Notes *(Continued from page 127)*

AVIATION ELECTRONICS HANDBOOK.

A practical handbook for aircraft owners, pilots, technicians and engineers, this text discusses the design, operation, and maintenance of automatic direction finders, distance-measuring equipment, omnirange, ATC transponders, weather radar, communications and instrument landing systems, etc. It also covers the aviation frequency spectrum, equipment standardization and installation, and shop facilities and regulations. (K. W. Bose. Indianapolis, Sams, 1962. 224p., $4.95.)

*SYSTEMS PHILOSOPHY.

This addition to the International Series in Space Technology is intended to provide a discussion of the key points and probable trends in systems technology, to make them intelligible to management and to furnish a general survey of the subject for the scientific community. All technical details have been relegated to the fifteen appendices which comprise the greater portion of the book. Many of the examples have been drawn from the area of airborne control systems. (D. O. Ellis and F. J. Ludwig. Englewood Cliffs, Prentice-Hall, 1962. 387p., $13.00.)

THE AGADIR, MOROCCO, EARTHQUAKE, FEBRUARY 29, 1960.

This book was written to provide the architect and structural engineer with knowledge on how to design structures—bridges, buildings, towers, dams—to withstand the stresses and strains caused by the earth's upheavals. The type and nature of the damage sustained by Agadir is recorded and illustrated to aid in the understanding of the dynamic characteristics of seismic forces. (Committee of Structural Steel Products of American Iron and Steel Institute. New York, American Iron and Steel Institute, 1962. 111p.)

(Continued on page 132)

Personals

(*Continued from page 76*)

K. W. McGrail has been appointed Assistant General Manager at Nova Scotia Light and Power Company Limited. Mr. McGrail was formerly Assistant to the General Manager. **F. M. Covert, Q.C.** was elected a Director of the company.

James F. Mills, M.E.I.C. (Man. Agree.) has been named chairman of the board and general manager of utility at Manitoba Telephone System. Mr. Mills has had 36 years' experience in the communications industry.

J. Stuart Anderson, M.E.I.C. (Man. '55) deputy minister of mines and natural resources, has been named vice-chairman of the board at Manitoba Telephone System.

R. E. Young, M.E.I.C. has been appointed assistant general manager of Alberta Government Telephones. Mr. Young has been with the department since 1926. He has been chief engineer since 1961.

Major B. Yarymowich, M.E.I.C. (Toronto '49) who was formerly employed by the Directorate of Equipment Policy, (DEP), has recently been appointed the RCEME member of the newly-formed Army Tactics and Organization Board at Camp Petawawa, Ont.

Roger V. Pierce has been elected President of the American Institute of Mining, Metallurgical, and Petroleum Engineers. Edward G. Fox has been elected President of the Society of Mining Engineers. The Society is a constituent of the AIME.

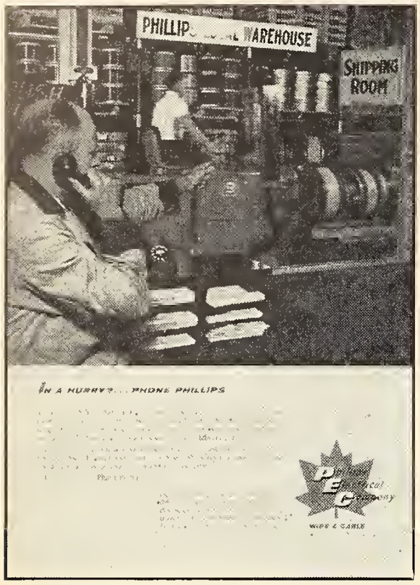
A. J. Chadillon has been appointed refinery superintendent at the Quebec Lithium Corporation. Mr. Chadillon joined the corporation in May 1962. He was formerly associated with Desjardins and Sauriol, Consulting Engineers.

B. Bernholtz has been appointed associate professor in the Department of Industrial Engineering at the University of Toronto. Mr. Bernholtz was associated with the Hydro-Electric Power Commission of Ontario since 1953 where he was Mathematician, Operations Research Group.

J. W. Smith, M.E.I.C. (U.B.C. '31) has been appointed assistant professor in the Department of Chemical Engineering at the University of Toronto. Mr. Smith, who was an Athlone Fellow at Imperial College, London, has been on the staff at the University of British Columbia.

Lawrence R. Weselake has been appointed Contract Maintenance Sales Engineer for the Sparling Division of Procor Limited. Mr. Weselake will be responsible for expansion of the contract maintenance and inspection programme which Sparling offers to refineries and general industry.

EIC CERTIFICATE OF ADVERTISING MERIT



The Phillips Electrical Company is currently running a series of advertisements featuring full colour action photographs showing the Company's products or services in action. On indication of its effectiveness is the fact that one of them has won The Journal's Monthly Award for August, 1962.

The advertisement is simply and cleanly laid out. The bleed photo shows a stockroom scene in a Phillips local warehouse shipping room, carefully but rather convincingly staged to show a busy expediter getting a busy lift-truck operator to pick up some supplies from a colourfully busy stock area. The heading, "In a hurry? . . . phone Phillips" spells it out, while a brief copy block reassures the reader that rush orders get special treatment.

The advertising of Phillips Electrical Company Limited is under the direction of Mr. A. M. Antliff. The winning advertisement was produced by the Toronto office of the Heggie Advertising Co. Ltd., Mr. Jack Heggie, account executive.

Each month a different panel of fifty Journal readers from across Canada is asked to nominate an award-winning ad of their choice from the viewpoints of ACCURACY—INFORMATION—ATTRACTION.

• Library Notes

(Continued from page 128)

PLASTICS PROGRESS, 1961.
The International Plastics Convention held in London in 1961 was concerned with recent developments in thermoplastics. Polyolefines, vinyls, and polystyrenes were discussed, and technical advances and commercial aspects for each described. The text is based on the papers given at the meeting and the discussions are also included. Four papers dealt with the processing of thermoplastics, and covered developments in single-screw injection molding; bottle blowing techniques; developments in extrusion practice; advances in equipment for manufacturing plastic film. (Ed. by Phillip Morgan. London, Iliffe, 1962. 181p., 65/-.)

THEORIE ELECTRONIQUE DE LA CATALYSE SUR LES SEMI-CONDUCTEURS.
The author, a professor at the University of Moscow, gave a course in Paris in 1960 on the fundamental principles of the theory that semi-conductors are the most important class of catalysts. This text is based on that course, and covers the electronic theory of catalysts; different types of absorption, chemisorption; the catalytic activity of semi-conductors; surface and internal inter-action in a semiconductor; correlation between catalytic activity and electric conductibility, etc. (T. Wolkenstein. Paris, Masson, 1961. 150p., 30NF.)

INSTRUMENT BALL BEARINGS.
The fourth in a series of surveys on instrument parts, this volume deals with small precision-grade ball bearings used in instruments and other light apparatus. The series attempts to list all available published material, in all languages, and includes 144 references. The topics covered in the survey are: types of bearings; tolerances; internal clearance and yield of ball bearings; performance; handling and mounting; elimination of shaft play; lubrication; load capacity and life. (P. J. Geary. Chislehurst, Kent, British Scientific Instrument Research Assoc., 1961. 73p., 23/6.)

THE WORLD ALMANAC, 1962.
As always, a vast amount of information is crammed into the Almanac, from the A.A.U. champions to the Yellowhammer State, taking in on the way such items as the consumption of beverages, Father's Day, units of mass, and Roman numerals. Information on Canada is included. In general the emphasis is on the U.S., although some information on the rest of the world is included. However, the Almanac will answer an amazing number of questions. (Ed. by Harry Hansen. New York, World-Telegram, 1962. 896p., $1.50.)

Consulting Services

RIPLEY, KLOHN & LEONOFF LTD.

Consulting Engineers

Soil Mechanics and Foundations

1930 WEST BROADWAY — VANCOUVER 9, B.C.

S. E. M. PROSPECTING LIMITED

Depth to bedrock determination by the

SEISMIC REFRACTION METHOD

for

Dam and Power Station locations: Rock Tunnels: Harbour Constructions and Canals: Larger Building Sites, etc., etc.

506 St. Catherine Street E., Montreal 24
Phone: VIctor 9-9252

Stadler, Hurter

& Company

CONSULTING ENGINEERS

Municipal, Commercial, Industrial, Process and Power, Engineering and Design.

1501 St. Catherine Street West, Montreal

NEW YORK • MEXICO CITY • PARIS • ZURICH

SWAN, WOOSTER ENGINEERING CO. LTD.

CONSULTING ENGINEERS

HARBOUR WORKS • INDUSTRIAL PLANTS • BRIDGES
HYDRO-ELECTRIC • STRUCTURAL DESIGN

Surveys • Reports • Design • Supervision

1334 W. Pender St., Vancouver 5, B.C. — 520 S.W. Yamhill St., Portland 4, Oregon. — 1685 Third Ave., Prince George, B.C.

B. B. TORCHINSKY & ASSOCIATES LTD.

PROFESSIONAL CONSULTING ENGINEERS

- Foundation Site Investigations
- Highway Design & Inspection
- Materials Testing Laboratory
- Asphalt Mix Designs
- Concrete Testing & Inspection

Drilling Rigs Located Throughout Western Canada

HEAD OFFICE
SASKATOON, SASKATCHEWAN
121 - 105th ST. EAST

REGINA — EDMONTON — WINNIPEG

PARTNER IN GIBB, UNDERWOOD & McLELLAN

CONSULTING ENGINEERS — LAND SURVEYORS

UNDERWOOD McLELLAN & ASSOCIATES LTD.

SASKATOON • WINNIPEG • CALGARY • REGINA

VANCE, NEEDLES, BERGENDOFF & SMITH, LTD.

CONSULTING ENGINEERS

EXPRESSWAYS • BRIDGES • AIRPORTS

Location and Cost Studies, Designs, Plans, Specifications
Supervision of Construction

35 SPRINGBANK AVE. — WOODSTOCK, ONTARIO

W. L. WARDROP & ASSOCIATES

(Management) Ltd.

ENGINEERING CONSULTANTS

Design and Inspectional Services for Municipal, Structural, Mechanical and Electrical Engineering Projects.

456 Notre Dame Avenue, Winnipeg 2, Manitoba. — 47 N. Cumberland Street, Port Arthur, Ontario

---

THE WARNOCK HERSEY COMPANY LTD.

Consulting, Inspection, Expediting, Testing.

Mechanical, Electrical, Civil Inspections • Soil Mechanics and Site Investigations • Chemical and Physical Tests • X-Ray and Ultrasonic Examinations • Research • Industrial Appraisals and Surveys • Expediting.

Head Office: 128 Elmslie Street, Montreal 32, P.Q.

Branch offices: St. John's, Nfld., Sydney, Halifax, Trenton, N.S., Saint John, N.B., Montreal, Ottawa, Peterborough, Toronto, Hamilton, London, Windsor, Sault Ste. Marie, Winnipeg, Regina, Edmonton, Vancouver.

WIGGS, WALFORD, FROST & LINDSAY

Consulting Engineers

INDUSTRIAL SURVEYS, REPORTS AND APPRAISALS
CIVIL, ELECTRICAL AND MECHANICAL ENGINEERING
DESIGNS, SPECIFICATIONS AND SUPERVISION

TORONTO	MONTREAL	OTTAWA
HUdson 1-6496	HUnter 1-7741	CEntral 6-5371

WOOD, McADAM & MAGOR

Consulting Engineers

STRUCTURAL - MECHANICAL - ELECTRICAL
DESIGNS, SPECIFICATIONS and SUPERVISION

4444 SHERBROOKE ST. — WESTMOUNT, P.Q.
WE: 5-8587-8588

REMEMBER!

It's to your own

ADVANTAGE

to use

M.E.I.C. A.M.E.I.C. S.E.I.C.

in all your correspondence

Denotes Membership of a Principal in the Association of Consulting Engineers of Canada

INDEX TO ADVERTISERS

NOVEMBER 1962

PUBLICATION OFFICES: The Engineering Institute of Canada, 2050 Mansfield Street, Montreal 2, Quebec, Canada.

Association of Consulting Engineers of Canada Incorporated

The following firms have principals who are members of this Association engaged as professional engineers in engineering work independent of salaried employment or sales promotion.

The revenue derived from the sale of advertising space assists the Institute in publishing THE ENGINEERING JOURNAL on a regular monthly basis. Listed above are the names of the Companies and individuals whose advertisements appear in this issue.

ADVERTISING OFFICES

QUEBEC: J. E. Donovan, Manager, Advertising Sales. Representative—Charles R. Amey, 2050 Mansfield Street, Montreal, Phone: VIctor 2-8121
ONTARIO: W. Morrison Day, 160 Eglinton Ave. E., Suite 103, Toronto, Phone: 485-0789
WESTERN CANADA: W. George Turner, 501 - 191 Lombard Ave., Winnipeg, Man., WH 3-9123
UNITED KINGDOM: H. A. Mackenzie, 4A Bloomsbury Square, London, W.C.1, England. Phone: HOlborn 3779
EUROPE: Gustav Elm, 41 Avenue Montaigne, Paris 8, France. Georg Linder, Wittelsbacher Allee 60, Frankfurt Am Main, West Germany.
NEW ENGLAND STATES: R. G. Melendy, 17 Maugus Avenue, Wellesley Hills 81, Mass. Phone: CEdar 5-6503
CHICAGO: W. Reynold Ratz, 549 W. Randalph St., Chicago 4, Ill. Phone: ST-2-8811
NEW YORK: John H. Boyd, 17 East 45th Street, New York, Phane: MUrray Hill 7-0654
CALIFORNIA: Dunkle/Lehman Company, 740 South Western Ave., Los Angeles, Calif. Phone: DUnkirk 7-6149

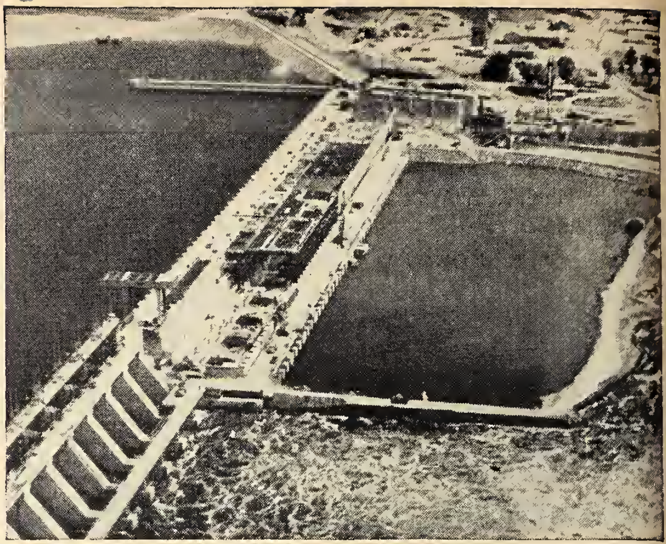
EIC

THE
ENGINEERING JOURNAL

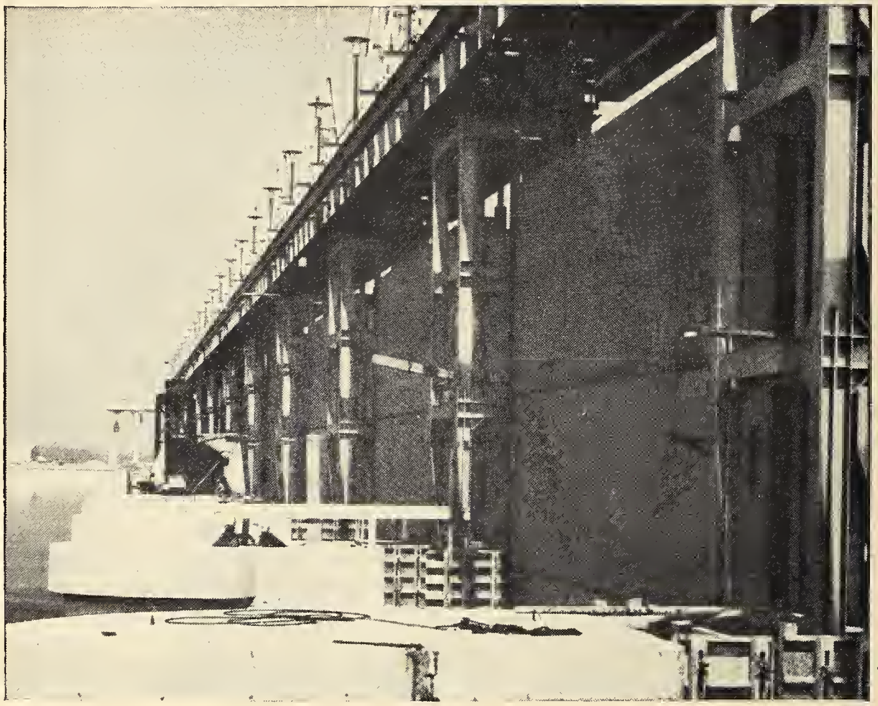
VOLUME 45 NUMBER 12 DECEMBER 1962

UBLISHED MONTHLY BY THE ENGINEERING INSTITUTE OF CANADA, 2050 MANSFIELD ST., MONTREAL 2, QUE., CANADA • TEL. VI. 2-8121

CONTENTS



Aerial views, left: prior to commencement, right: nearing completion of the Carillon project showing: foreground—sluice gates, 50′ wide, 31′6″ high. Middle distance—powerhouse section intake gates, 17′ wide, 35′ high. Background—lock structure.



Sluice gates—upstream view of sluice-way-section with gates raised.

Photos: Courtesy Hydro-Québec

IN THIS ISSUE

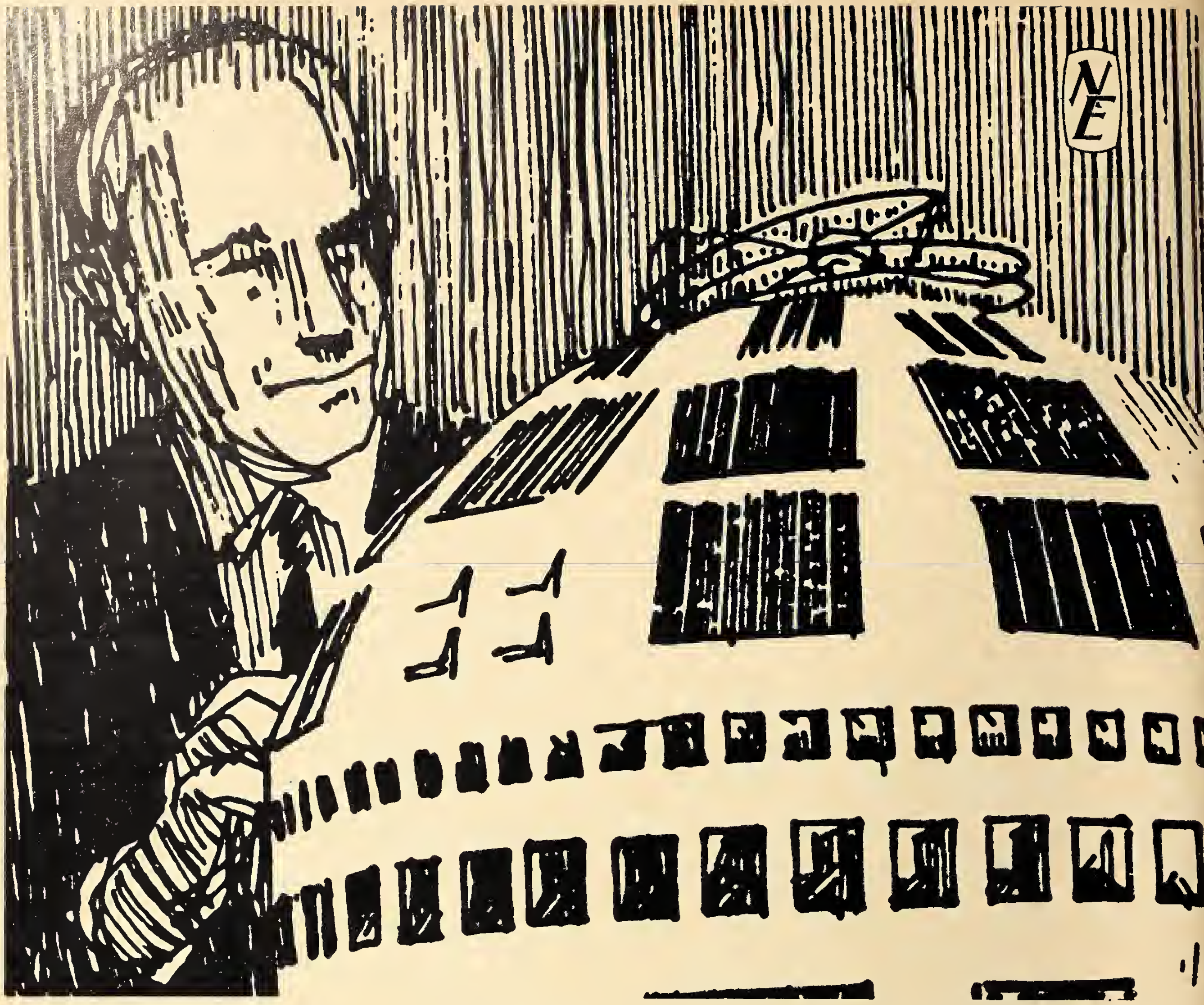
Transportation is a matter of vital concern in the Canadian economy because of the great distances from the areas of production to the areas of consumption. In their paper, *"Pipeline Flow of Capsules: Potential Industrial Application"*, G. W. Hodgson, Head, Petroleum Division, and L. Henry Bolt, M.E.I.C. Research Engineer, both at Research Council of Alberta, state that the cost of pipeline methods of transport falls between shipping and rail methods. While inland waterways play a substantial and increasing role in Canadian transportation, there is justification for trying to extend the application of pipeline methods to commodities not presently amenable to pipeline transport. Second-generation pipelining shows promise, but it is limited in its application and recourse must be made to third-generation pipelining in which the goods to be moved must be placed in the fluid streams as large capsules which flow as segments of the stream. This paper considers the basic applications of investigational programs, and some of the over-all technology involved. About 25% of the total transportation traffic in Canada centres upon the movement of grains, mineral solids and chemicals. Conventional oil and gas pipelines already account for about 20% of the total freight traffic. The major cost in capsule pipelining as in conventional pipelining, relates to the capital costs of the system. To this is added the surcharges for additional packaging and handling equipment, and for increases in pressure gradients.

"Settlement Studies on the Mt. Sinai Hospital, Toronto", by C. B. Crawford, M.E.I.C. and K. N. Burn, M.E.I.C. of the Soil Mechanics Section, Division of Building Research, National Research Council, Ottawa, reports settlement measurements on a large structure found on a reinforced concrete mat over glacial till subsoil, and compares these estimates derived from laboratory testing. The modulus of elasticity of the subsoil derived from full-scale field measurements is compared with laboratory values. The performance of this type of foundation is discussed.

J. S. MacKelvie, Electronics & Electrical Engineer, H. Hollitscher, Laboratory Engineer and E. C. Elgar, Mechanical Engineer, all with Canadian General Electric Co., in Peterborough, Ont., in their paper, *"Loss Measurement in Magnetic Steel Above Saturation Density with Controlled Flux Waveform"*, describe a means of producing controlled flux waveforms in standard steel samples over a range of method of measurement of loss is used successfully to avoid the difficulties associated with the electrical measurement of loss at saturation flux density. Measurement of peak flux density is made with an average reading voltmeter attached to a search coil which is compensated for air leakage flux. Peak magnetic field strength is measured with another search coil.

COVER ILLUSTRATION

An increasingly interesting form of transportation is the pipeline flow of capsules. The lead paper in this issue of the Engineering Journal deals with the potential industrial applications of pipeline flow of capsules and this is symbolized in the cover illustration which shows a typical pipeline in the Canadian West.

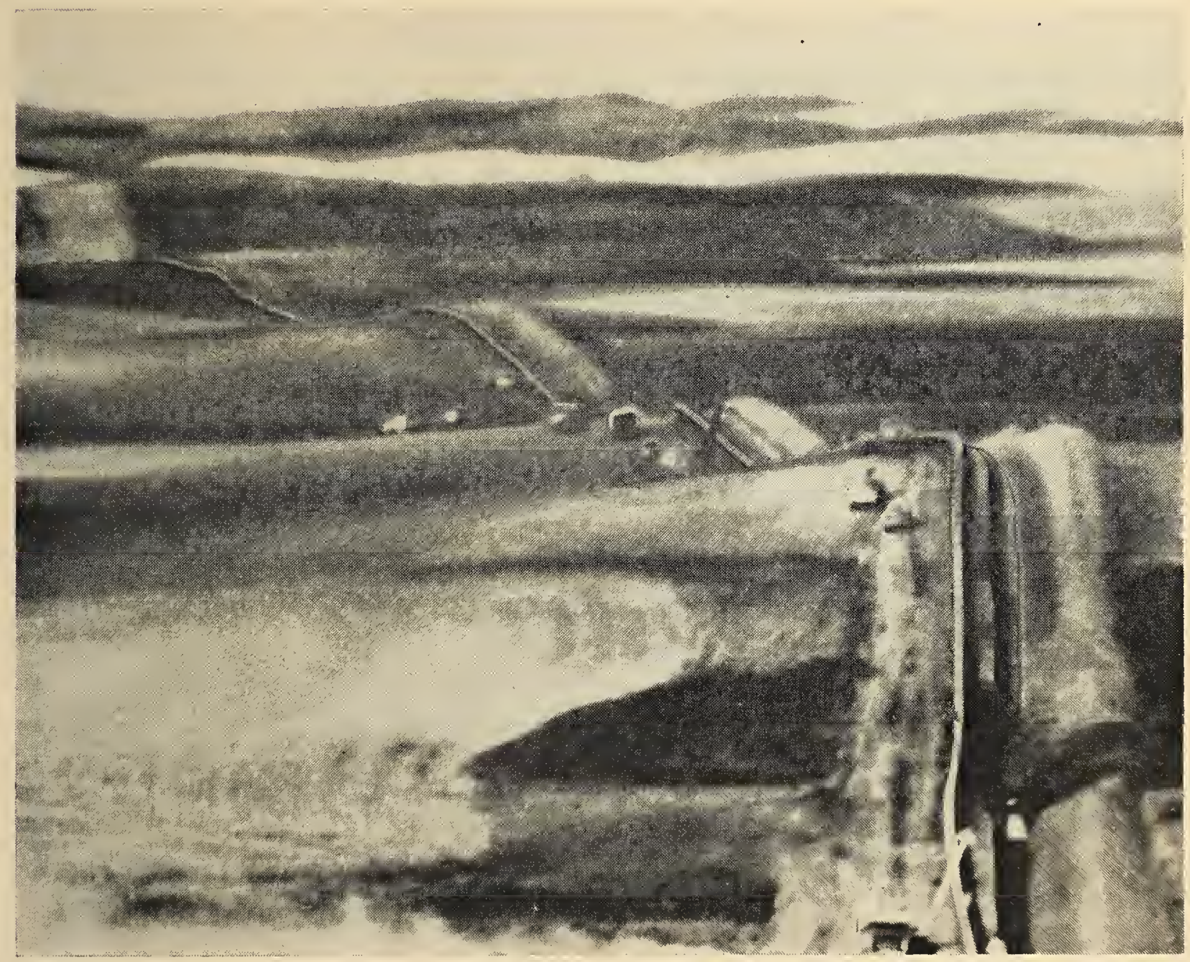


THE PIPELINE FLOW OF CAPSULES

Potential Industrial Applications

G. W. Hodgson,
Head of Petroleum Division,

L. Henry Bolt, M.E.I.C.
Research Engineer, Research Council of Alberta



THE COST of overland transport by pipeline tends to approach that of transport by water, and attention is attracted to the possibilities of extending pipeline technology beyond those applications which presently enjoy the economies inherent in pipelining. In this connection it is convenient to think of pipelining undergoing a systematic evolution experiencing several generations of growth such as have been outlined[1] as follows:

First generation—the movement of fluids;
Second generation—the movement of solids in suspension;
Third generation—the movement of materials in capsules.

material. Since one of the major applications for capsule pipelining appeared to be the movement of grains in pipelines, attention centered upon the use of a disposable film, partly because this could most readily be evaluated cost-wise. A reasonable estimate of the cost of such film did not seem to indicate that the method was beyond all economic reason. Further, it was recognized that capsule pipelining would include the movement of capsules which were in fact solid ingots of the material to be transported, such as sulphur, and that the cost of packaging in such cases would be very low, thus making the whole operation worthy of systematic study.

A systematic study was undertaken and it concentrated upon developing the science of the concept, leaving the technology of it until later, as illustrated in Fig. 3. The science was developed through both theoretical and experimental approaches. The theoretical study dealt with establishing suitable mathematical models of the capsule movement along the lines described by Charles[4]. The experimental approach consisted in the main of setting up a laboratory pipeline 1.25 in. in diameter and about 30 ft. long and observing and measuring the flow of a wide range of single capsules under a comprehensive variety of flow conditions. The principal factors studied were the effect of capsule diameter, length, density, and end shape, fluid viscosity and density, and gradient of the pipe. Much of the indicated laboratory work has been completed and has been recently reported by Ellis[5]. In general the capsules flow in a manner similar to the flow of oil slugs in water. The flow characteristics of capsules heavier than the supporting fluid approach those of the ideal equal-density systems with the capsule velocity exceeding the average velocity of the fluid provided the capsule diameter is about 90% of the internal diameter of the pipeline.

Assuming that the scientific aspects of the capsule system are well in hand, it is now important to consider the second-stage economics — Economics II of Fig. 3 — before undertaking a comprehensive examination and development of the technology of capsule pipelining. In this connection, it is the purpose of the present paper to discuss the potential commercial application of the new pipelining concept so that an understanding might be gained of the proper course of further development, if any. To examine Economics II, it is necessary to consider the manner in which the basic economics of pipelining would be altered in making capsule pipelining mechanically feasible.

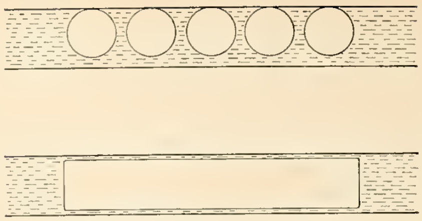


Fig. 2. Basic pipeline capsule shapes—cylinder and sphere.

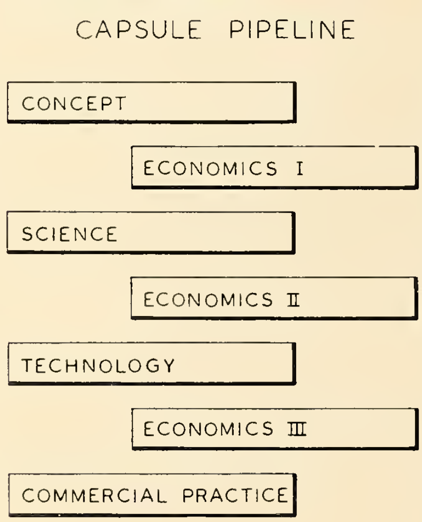
Basic Economics of Capsule Pipelining—Economics II

It is important to note at the outset that only the science of capsule pipelining is well understood; the technology of capsule pipelining has not yet been investigated to any significant degree.

The principal cost of a pipeline relates to the provision and installation of the pipeline pipe. Roughly half the cost of the installed pipe is for the steel itself; the remainder, for the installation. Operating pressures in capsule pipelines would probably be less than in conventional oil pipelines, particularly in instances when the material to be shipped is sensitive to external mechanical loading as in the case of grains. On the other hand, some additional care might have to be exercised in finishing the interior of the pipe particularly at the welds so that snagging of the capsules could be avoided. There is no reason to believe that additional costs might be incurred as a result of rough terrain although the gradient effects are not well defined at this time. A surcharge of about 20% might be envisaged to cover minor modifications in the provision and installation of the pipe for a capsule pipeline.

About 10% of the total cost of a conventional oil pipeline relates directly to the pumping stations involved. The pumping stations and associated mechanical gear for a capsule line would be significantly more complex than those for a conventional line. It would be necessary to establish a lock-bypass system at each station through which the line pressure could be increased. This would involve additional piping and valving as well as a local and regional control system. Accordingly, it is necessary to provide for about 100% increase in the cost of pumping stations, for the additional installations. The size of the stations for given volumetric flows would not need to be increased since pressure gradients for capsule-filled streams in many cases are likely to be lower than those for the stream itself. Thus, the capital cost of a capsule pipeline would appear to be about 25-30% more than that of an equivalent oil pipeline.

Fig. 3. Steps in the development of the capsule pipeline concept.



It is necessary, however, to note that the load factors are different, since the "cargo" in a capsule line may be considered as occupying only about 60% of the volume of the pipe. This consideration would therefore indicate a further increase in capital cost to about 200% of that of a conventional line carrying the same volume of "cargo". This represents a surcharge of 100% on ordinary pipelining capital costs and the same magnitude of surcharge would in all probability apply to maintenance of the line as well.

Operating expenses for a capsule line would be expected to be greater than for a conventional line, not for increased energy demands, but rather for the operation of the pumping stations where careful over-seeing of the movements of the capsules and groups of capsules must be maintained. In all probability a complex data processing system would be employed. A reasonable estimate for the surcharge on operating expenses might be 200%.

The supporting fluid in a capsule pipeline system could be either an inexpensive expendable fluid such as water, or a fluid such as crude oil for which a transportation credit might be claimed as a result of the transportation of the fluid itself. In the one case, a minor expense item of a few per cent of the over-all operation would result; in the other, a significant credit might be obtained toward the cost of the operation. Although a credit of 5-20% is indicated in some instances, it is perhaps wise at this time to overlook such benefits and consider the capsule pipelining on its own merits.

First generation pipelining has been limited to simple fluid systems which flow by virtue of the fact that the materials being transported are liquids or gases. This generation of pipelining has been in practice for thousands of years and has seen its most vigorous application within the last century, since the discovery of oil and gas in quantity.

Second generation pipelining is based upon the fact that it is possible to move solids in fluid streams by the expedient of reducing the particle size of the solid material to such an extent that the particles tend to become part of the fluid stream. In this manner the particles are readily held in suspension, and the entire system flows more or less like a homogeneous fluid. Second generation pipelining has seen limited development to date but has reached commercial application in a few isolated instances. A good review of the movement of solids in suspension has been recently published[2] with a discussion of the principles involved and a listing of the applications which have been made.

While both first and second generations of pipelining are well advanced and have reached commercial application, there are limitations to the applications of each of them insofar as the movement of solids is concerned. Few solids can be taken into solution for the application of first generation methods, and serious difficulties arise in the application of suspended solids methods when the solids are very dense and when the systems are such that the solids and supporting fluids tend to contaminate one another, or when the solid is not mechanically strong enough to withstand the mechanical stresses imposed upon it by the turbulence in the flowing stream.

Clearly, then, there is merit in considering the next generation of pipelining in attempting to extend the application of pipeline methods to a wider spectrum of commodities. This deals with the flow of solids in massive forms in a fluid stream, and is known as capsule pipelining.[1]

Capsule Pipelining

Capsule pipelining is a method in which the commodity to be moved is incorporated into a fluid stream not as minute particles as in suspended-solids pipelining but rather as large coherent segments of the flowing stream. The theory of capsule pipelining was developed through its initial stages by Hodgson and Charles[1] and will be only briefly discussed in this communication.

Basically, the concept of capsule pipelining arose from the observation that slugs of oil are stable configurations of flow when water is added to a stream of oil flowing in a pipeline[3] as illustrated in Fig. 1. The slugs travel in an annulus of water and are marked by a diameter of 60-90% of the internal diameter of the pipe. It has been shown that such movement is characterized by two significant features:

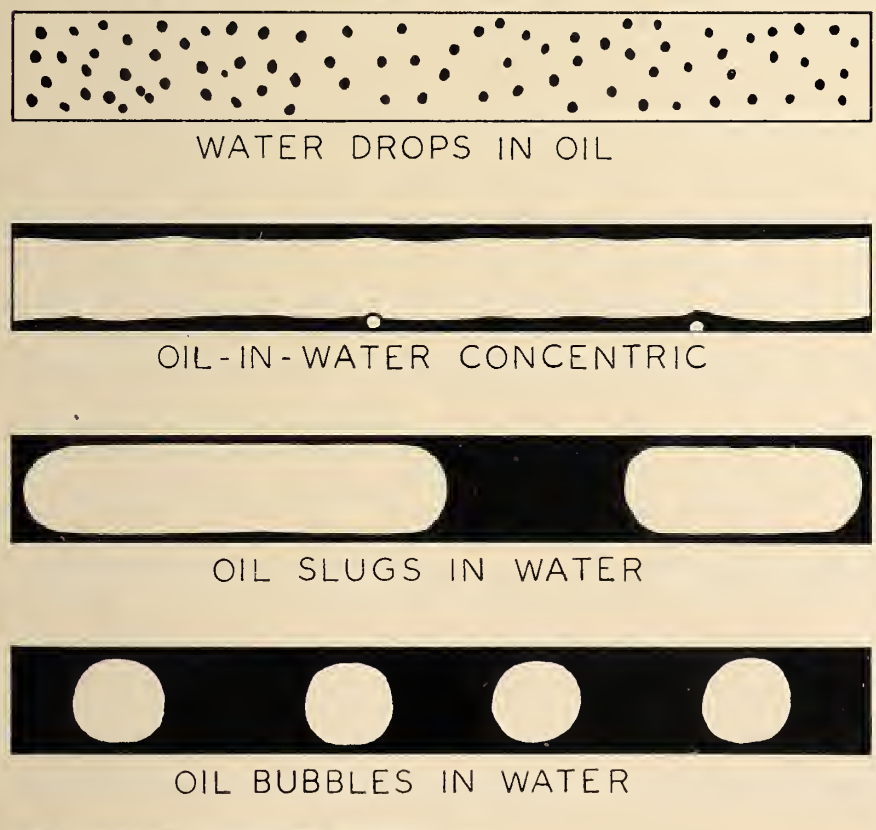
1. The rate of movement of the slug exceeds that of the supporting fluid.

2. The pressure gradient for a stream consisting of oil slugs and their supporting fluid is *less* than that for the same volumetric flow of the supporting fluid alone, when it is in turbulent flow.

These two features apply over a wide range of flow conditions, and have considerable significance in the general topic of capsule pipelining.

Capsule pipelining is a logical outgrowth of the observations surrounding the flow of oil slugs in water. In first principle it is a matter of considering the slug as a package containing the material to be shipped, as illustrated in Fig. 2. It is important to note that there are two basic capsule forms. For one, the shape is that of a cylinder; for the other, a sphere. Both were apparent in the oil-in-water investigations, and both were stable over wide ranges of flow conditions. The adoption of capsule pipelining as the third generation of materials pipelining was thus indicated, and consideration was immediately given to a comprehensive development of it in the interests of extending pipelining techniques to areas presently out of reach of such methods.

Fig. 1. Flow configurations of oil and water in a pipeline (3).



Development of the Concept

While pipelining in general is marked by transportation costs which are much lower than those of other methods of overland transport, it is not sound to assume that capsule pipelining can claim the same economies of operation without a detailed examination of the various special factors peculiar to the operation. It is perhaps of interest to formalize the development of such a concept through its various stages of growth as illustrated in Fig. 3, so that a growing understanding of the potentialities and limitations of the method might continually guide the development operations.

The section labelled Economics I was a brief examination of the obvious economic limitations inherent in the capsule concept. The various factors inherent in fluid pipelining were considered, and reasonable and conservative guesses were made to estimate the over-all cost of pipelining by capsules. It appeared at the time that the major uncertainty was that of assessing the cost of supplying a suitable packaging or encapsulating

TABLE I

Crude Oil and Natural Gas Production Western Canada 1960

Crude Oil	*Thous. BBL**	*Thous. Tons†*
Manitoba	4,718	700
Saskatchewan	53,000	7,870
Alberta	132,100	19,620
British Columbia	950	14
	190,768	28,204
Natural Gas	*Mcf**	*Thous. Tons‡*
Manitoba	...	...
Saskatchewan	33,000,000	148
Alberta	370,000,000	1,660
British Columbia	85,067,000	382
	488,067,000	2,190

*Source: Canada Year Book 1961
†Based on Crude Oil 35° A.P.I.
‡Based on Natural Gas Mol. Wt. 17.

In the initial examination of the cost of capsule pipelining in Economics I it was recognized that the cost of encapsulation would be a major item. The development of the science of the concept reduced many of the uncertainties in most of the component factors but was less useful in delineating the areas of confidence in the packaging operation. However, the regions of unstable flow behaviour were found to be quite limited and could be controlled to an appreciable extent by adjusting the end configuration of the capsule. Nevertheless it is still difficult to estimate the encapsulation costs. Many variations in the mode of encapsulation may be considered, ranging from a more or less rigid container to a minor thin protective coating. The containers may be re-usable or expendable; if they are re-usable, provision must be made for returning them to their point of origin for re-use; and an estimate must be made of the number of "trips" which could be expected during the life of the package; if they are expendable, a salvage credit may be claimed, particularly if the salvaging takes place in an area of higher market value for the packaging resin. Perhaps it would be adequate at this time to think of the provision and installation of a tough disposable film as a kind of limiting case. This might be considered adequate for the handling of products such as grains and powdered coal, as well as for other more readily handled materials. Polyethylene and polypropylene might be considered as typical suitable packaging films at this stage, and Fig. 4 illustrates in a general way how the costs for such film would depend on the capsule diameter and film thickness. It is evident that encapsulation costs are surely major items in the capsule pipeline operation, but only for capsules needing this type of covering.

It is obvious from this figure that the unit costs of capsule pipelining are a function of the volume of material being handled. It is now reasonable to look ahead to the potential applications of capsule pipelining and establish what volumes of material might be handled in this way. In this manner some estimate may be made of the unit costs of capsule pipelining so that a reasoned judgement might be made of the advisability of entering into a comprehensive investigation of the Technology of Fig. 3.

Fig. 4. Cost of encapsulation per cu. ft. of cargo as a function of capsule scale-up over a range of capsule diameters and various plastic film thicknesses when the capsule length equals five capsule diameters, based on a disposable film costing about 50 cents/lb. in place.

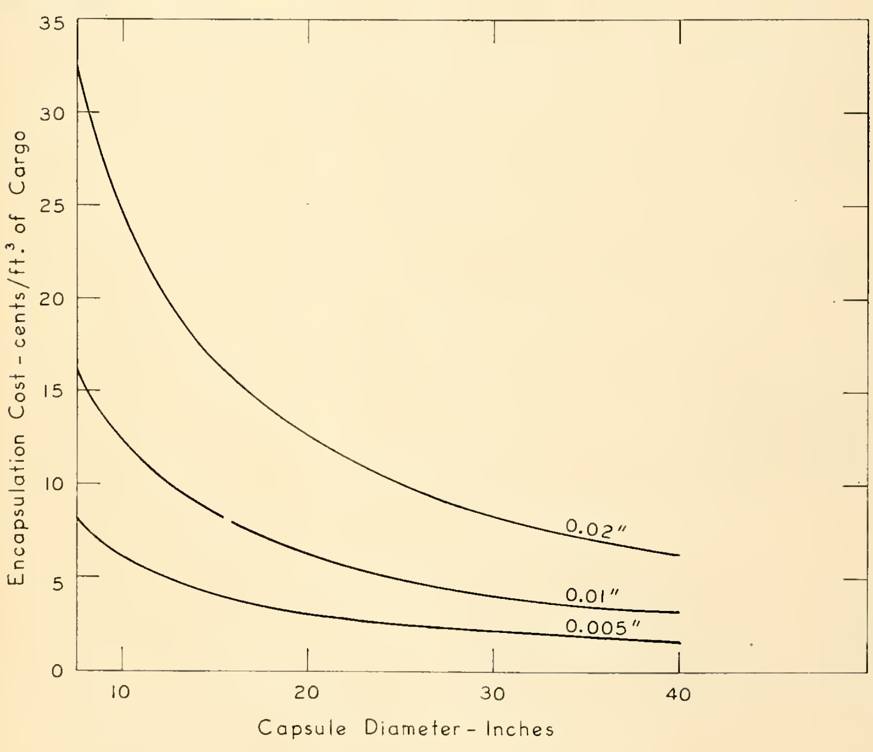


TABLE II

Ten-Year Average Total Production of Principal Grains in the Prairie Provinces

Harvest Years 1951-1960

	*Mill. Bushels**	*Mill. Tons*
Wheat	474	14.2
Oats	289	4.9
Barley	231	5.5
Rye	12	0.3
Flaxseed	18	0.5
Total	1,024	25.4

*Source: Dominion Bureau of Statistics, via The Canadian Wheat Board.

Potential Applications of Capsule Pipelining

Assuming for the moment that almost any bulk commodity could be handled in a capsule pipeline system, let us now consider some of the major potential items in turn. To give a basis for comparison in equivalent units, Table I lists the major products which are currently being handled in Canada in pipeline systems. These include only oil and gas. There are no long-distance movements of materials by slurry pipelining in Canada, although about 1.25 millions tons of coal[6] and 0.25 million tons of gilsonite[7] are being pipelined annually in water slurries in the United States.

Grain

The western prairies of Canada produce large tonnages of grains as summarized in Table II. Much of the grain, 47%, moves to export markets and to domestic markets outside the areas of production as illustrated in Fig. 5. Thus, major grain movements out of the western plains of Canada take place, in the amount of about 12 million tons, comparable with current oil and gas tonnages. Such freight traffic would surely bring a pipeline handling grain into sizes of pipes which are considered "economic" in present-day practice. For example a 300-million-bushel, about 9-million tons, annual operation would appear to require a 30 in. pipe size.

Minerals

Sulphur production in Western Canada is rising sharply with a present installed capacity in Alberta of 5440 long tons per day as detailed in Table III. Additional production of about 1000 tons per day takes place in northeastern British Columbia. At a likely rate of production the annual sulphur output in Western Canada will probably amount to about 2 million tons. While this is appreciably lower than the grain production,

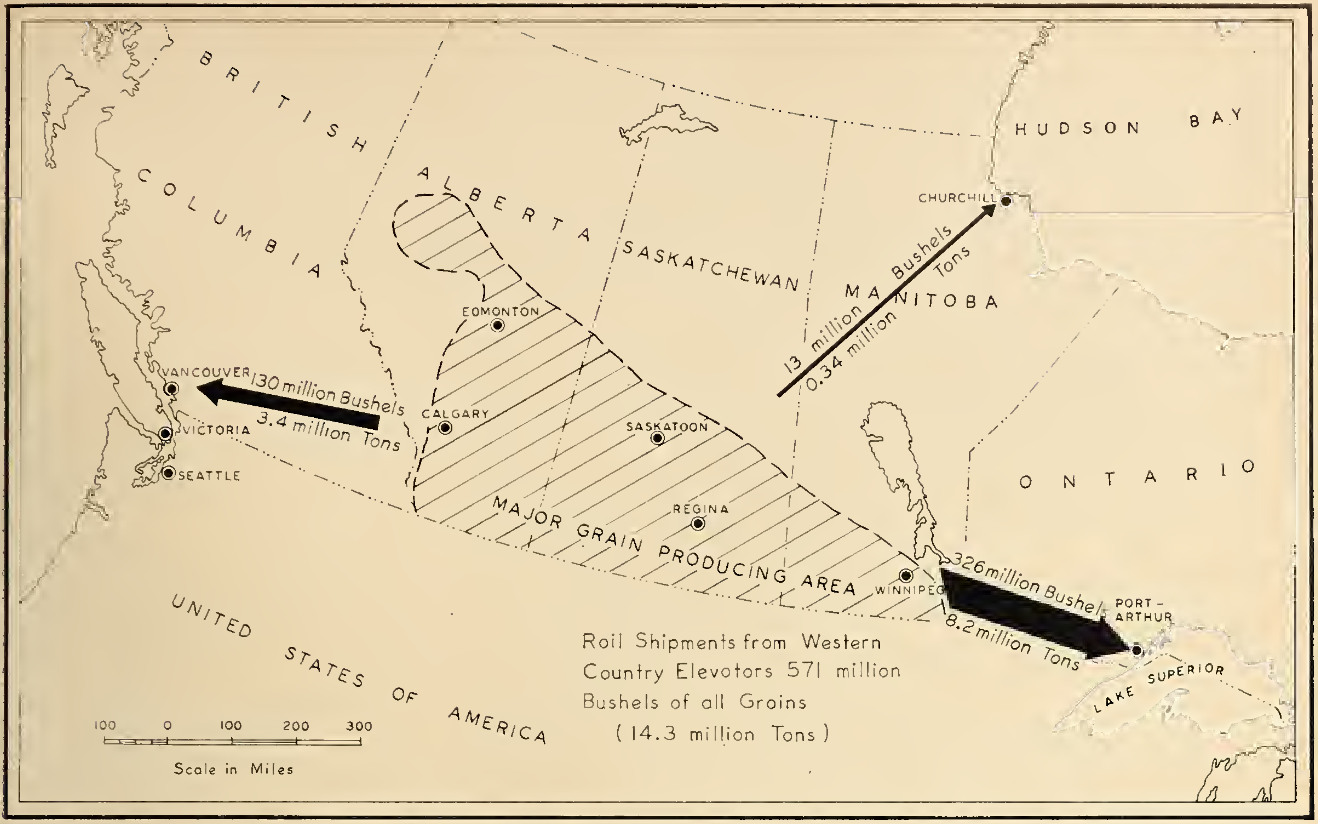


Fig. 5. Ten-year average of bulk grain movements from Western Canada from 1951-1960.

TABLE III
Sulphur Plants—Alberta—1962*

Location	*Initial Operating Year*	*Sulphur Productive Capacity, Long Tons/ Day*
Jumping Pound...	1952	135
Turner Valley....	1952	30
Redwater........	1956	9
Pincher Creek....	1957	900
Okotoks.........	1959	370
Nevis...........	1956	76
Nevis...........	1959	120
Innisfail.........	1960	100
Rimbey..........	1961	250
Wildcat Hills.....	1961	105
Windfall.........	1962	650
Carstairs.........	1962	60
Burmis..........	1962	375
East Calgary.....	1962	860
Waterton........	1962	1,400
Total......................		5,440

*Source: D. I. Istvanffy, Symposium on Petrochemicals, Edmonton, March 15, 1962. From "An analysis of the sulphur industry in Alberta" by W. G. Brese. Research Council of Alberta. Information Series No. 38, 1962.

nearly all of it will normally be intended for the export trade, and will therefore become a major export item from Western Canada. In itself it would account for a capsule pipeline about 10 in. in diameter, a size not much below that of commercial long-distance oil pipelines.

Minerals such as sodium sulphate with a production of 0.2 million tons per year in Saskatchewan may not be of sufficient size to warrant the consideration of capsule pipelining. However, the forthcoming production of potash from the same province of over a million tons per year[8] would present a more favorable situation. The most potentially interesting possibilities are those mineral deposits under consideration for iron, lead and zinc in northern Alberta which may well find a large outlet market, if the transportation costs to the West Coast are sufficiently low, in the predicted expansion of the Japanese mineral industry.[9]

Coal is another mineral product which may have "export" markets outside of its areas of production in Western Canada, especially Alberta with half of the Canadian coal reserves. It is difficult to predict what markets might develop if the cost of transporting coal were reduced, but perhaps it would be worthwhile to consider that two different potential markets exist, one for coking coal and the other for thermal coal for power production. The coking coal would normally find its way into the world market, say through Vancouver; the thermal coal would tend to move east to the Lakehead. Both operations could be pictured as handling several million tons per year. At present about 0.3 million tons of coking coal are being shipped to Japan from the West Coast, with a highly significant indicated future demand from Japan as high as 15 million tons per year by 1970.[9]

TABLE IV
Coal Production—Alberta and Saskatchewan (subject to revision)

	1960 Strip (Tons)	*Underground (Tons)*
Alberta..........	1,156,265	1,235,434
Saskatchewan.....	2,170,797	....

Source: Fuel and Mining Division, Mines Branch, Department of Mines and Technical Surveys.

While slurry pipelining in crude oil is being considered for coal transportation,[10] there is merit in considering capsule transport as well, particularly in the case of coking coals where contact of the coal with the supporting crude oil might interfere with subsequent coking operations. Current coal production in Alberta and Saskatchewan of about 4.6 million tons per year is given in Table IV.

Chemical products

Western Canada is a major producing area for chemicals and petrochemicals as listed in Table V. The

TABLE V
Estimated Production of Chemicals and Petrochemicals Alberta 1960

	Tons
Inorganic Chemicals (e.g. Fertilizers)...	491,700
Organic Chemicals —Liquid (e.g. methyl alcohol).....	53,800
Organic Chemicals—Solid (e.g. Polyethylene, cellulose acetate flake)....	48,900
Metals (e.g. Nickel)..................	23,600
Total..........................	618,000

tonnages involved however are relatively small and a capsule pipeline for the movement of such materials alone would not be justified. On the other hand, this does not rule out the possibility of such chemical products being moved in a capsule pipeline.

Forest products

Forest products in Canada are produced for the most part in British Columbia, Ontario and Quebec. The tonnages are summarized in Table VI, and about 10 million tons are converted into pulp annually. There are few disadvantages to pipelining wood pulp in suspension in water, and capsule pipelining may have very little to offer.

Common Carriers

Clearly there would be adequate traffic to support capsule pipelines for grain and perhaps for sulphur and other commodities as well. It should be recognized that a given capsule pipeline could handle more than a single commodity however, and could in fact operate as a common carrier. If so, one might picture, for example, common carriers running both east and west from the central plains of Western Canada where there is no competition from water transport. It is now important to try to assess in a general manner what the costs of such systems might be, from an understanding of the unit costs and the surcharges outlined above.

TABLE VI

Equivalent Volume of Solid Wood Cut in Woods Operations by Province—1959

	M. cu. ft.
Newfoundland	96,695
Prince Edward Island	10,594
Nova Scotia	89,612
New Brunswick	172,602
Quebec	877,158
Ontario	531,528
Manitoba	51,766
Saskatchewan	44,621
Alberta	135,003
British Columbia	1,173,965
Yukon and N.W.T.	2,843
Total	3,186,387

Assuming 1 cu. ft. = 50 lb.

TOTAL 80 million tons (Approx.)

Source: Canada Year Book, 1961

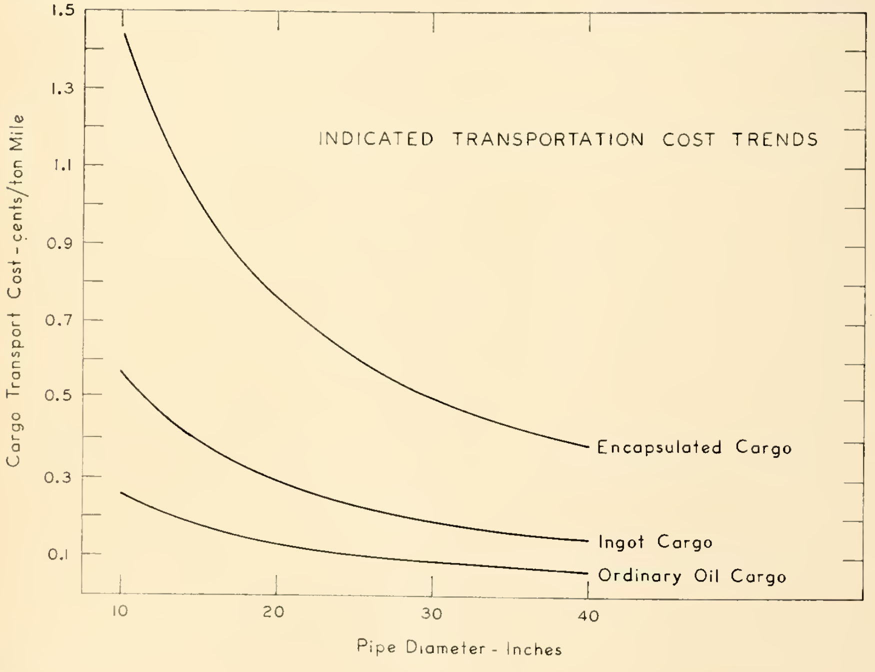
Taking capital and direct operating costs of conventional pipelining to be 80% and 20% of the total operating costs, and then applying the indicated capsule line surcharges of 100% and 200% respectively, the total surcharge for capsule pipelining would appear to be 120%. A further surcharge is necessary for cargo requiring an encapsulating film and is dependent on the price of the encapsulating material in place. The effect of this is illustrated in Fig. 6. The base curve gives a general indication of the cost of moving a liquid such as crude oil in a conventional pipeline of the economic size for the throughput under consideration. Imposition of the capsule pipeline surcharge raises the unit costs by 120%, and this is illustrated in Fig. 6 by the "ingot cargo" curve which pertains to a material handled in capsule form without any significant amount of packaging material around it. Capsule transport of sulphur would be a good example of an ingot capsule system.

The third curve in Fig. 6 is labelled "encapsulated cargo", and pertains to a fully packaged commodity, such as a grain. The example, arbitrarily chosen, was for a 20-mil film and for a pipeline system 1000 miles long.

It is clear that while an ingot cargo, e.g. sulphur, could be handled profitably at much lower throughputs than encapsulated cargo, e.g. grain, the grain could be handled at even lower rates provided the throughput for grain was in the range of several hundred million bushels annually, corresponding to the 30 and 40 in. pipe sizes. These observations apply to single commodity lines; common carriers would of course be in a preferred position.

The data in Fig. 6 indicate in a general manner that the capsule rates may be low enough to compare favorably with current bulk freight rates provided there is an assured market for large volumes of bulk commodities. However, it cannot be said at this point that the indicated capsule rates are in any sense firm, since the present analysis deals only with Economics II lying between "Science" and "Technology" in the development of the capsule pipelining concept.

Fig. 6. Indicated transportation cost trends as a function of pipe diameter assuming: 1. Cost of encapsulating material is 50 cents/lb., in place, using a plastic film 0.02" in thickness (Fig. 4). 2. Capsule length equals five capsule diameters. 3. Diameter of capsule equals 0.85 pipe diameter. 4. Density of cargo approximately equal to that of water. 5. Average fluid velocity equals 5 ft./sec. 6. 1000 mile pipeline. The base line for ordinary oil cargo gives costs per ton mile slightly higher than those quoted by Leslie Cookenboo, Jr., "Costs of Operating Crude Oil Pipelines", Rice Institute Bulletin, April, 1954.



Conclusion

An examination of the development of the capsule pipelining concept through its inception, initial economic analysis, the establishing of its science, and a secondary economic analysis indicates that the method is sufficiently attractive to warrant further investigations, investigations concerned primarily with the technology of the method.

References

1. Hodgson, G. W. and Charles, M. E., **The pipeline flow of capsules. Part 1. The concept of capsule pipelining.** In press.
2. Charles, M. E. and Govier, G. W., Engineering Journal, Vol. 44, No. 5, p. 50 (1961).
3. Charles, M. E., Govier, G. W. and Hodgson, G. W., Can. J. Chem. Eng., Vol. 39, p. 27 (1961).
4. Charles M. E., **The pipeline flow of capsules. Part 2. Theoretical analysis of concentric flow of cylindrical forms.** In press.
5. Ellis, H. S., **The pipeline flow of capsules.** Paper read at the Edmonton Conference of the Chemical Institute of Canada, May 27-30, 1962.
6. Dauber, C. A., Coal Age, Vol. 62, p. 84 (1957).
7. Bond, R. K., Chem. Eng., Vol. 64, p. 249 (1957).
8. Tyre, Robert, Western Bus. Ind., Vol 36, No. 3, p. 38 (1962).
9. The Editor, Western Bus. Ind., Vol. 36, No. 3, p. 24 (1962).
10. Berkowitz, N., Hodgson, G. W., Moreland, C. and Round, G. F., Oil in Canada, Vol. 13, No. 11, p. 25 (1961).

SETTLEMENT STUDIES on the Mt. Sinai Hospital, Toronto

C. B. Crawford,
Head, Soil Mechanics Section,
Division of Building Research,
National Research Council, Ottawa.

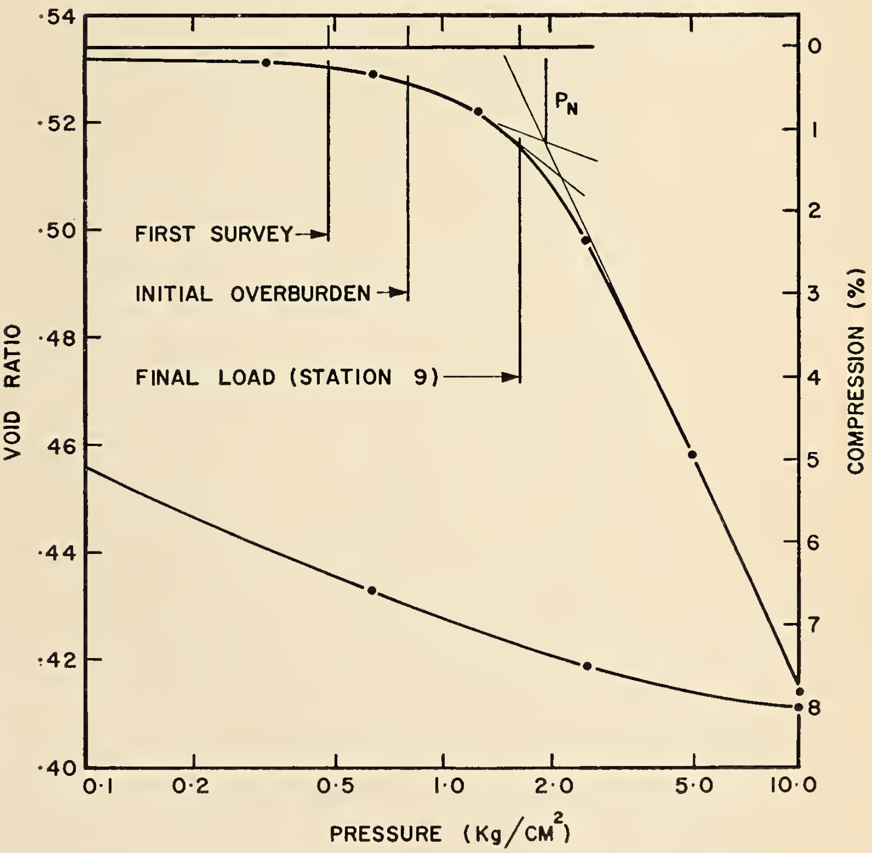
K. N. Burn,
Soil Mechanics Section,
Division of Building Research,
National Research Council, Ottawa.

THE CONSTRUCTION of any large structure on soil without the benefit of piles or caissons to transfer the building loads down to bedrock or other solid strata is sometimes carried out with much apprehension. Nevertheless, the savings to be gained by avoiding the use of deep foundation units is always an attractive possibility. In an effort to assist in the accumulation of documented experience on the performance of large buildings thus founded on soil, the Division of Building Research of the National Research Council has co-operated with design engineers and builders in measuring building settlements. This report of observations on the Mt. Sinai Hospital in Toronto from the beginning of construction in 1950 through several years of operation is the result of such a co-operative effort.

Geology and Site Conditions

The southern half of the city of Toronto is located on the bed of glacial Lake Iroquois; the shoreline of the glacial lake lies about three miles north of the Toronto waterfront. Near the old shoreline, the Lake Iroquois beach sands, several feet

Fig. 1. Consolidation test results.



thick, may lie over glacial till but to the south the sand layer is thin or non-existent. Interglacial sands and clays are found between the Wisconsin till and the lower Illinoian till. Bedrock is Ordovician shale and limestone.[13]

The bedrock rises gently to the north from the Toronto waterfront. The depth of overburden increases correspondingly so that the ground surface rises at a rate of a little more than 1 ft. in 100 ft. from the shores of Lake Ontario to the old shoreline of glacial Lake Iroquois. The Mt. Sinai Hospital is located on University Avenue at Elm Street, just over a mile from the Toronto harbour. The site is at El. 318, 70 ft. above normal lake level.

Excavations for the Yonge Street line of the Toronto Subway revealed large boulders in the glacial till and confirmed the suspicion that pervious soil strata (perhaps of the interglacial beds) carried water under artesian head.[4]

During the last two years the many excavations made in the course of constructing the University Avenue line of the subway has provided an opportunity for detailed mapping of soil deposits immediately in front of the Hospital.[3] This work revealed a soil profile about 55 ft. thick, the lower 15 ft. being very dense "York varved clay" and "York till" of Illinoian glacial stage. Above this is about 15 ft. of the interglacial stage "Toronto Formation" consisting of stratified sand, silt and clay. The upper 25 ft. of soil is the Sunnybrook till, a massive silty till of Wisconsin age. The southern limit of Lake Iroquois sand is in the vicinity.

At the time of construction of the hospital a number of soil borings were made on the site to obtain representative samples of the subsoil. These revealed some filled ground but generally a surface mantle of 8 to 10 ft. of fine brown sand lying over 40 to 45 ft. of grey glacial till containing varying amounts of sand and stones. Refusal (presumably at bedrock) was met at elevations ranging from 260 to 265 ft.

Standard penetration tests (with a 145 lb. weight falling 30 in. on a sampling spoon) were done at about 5 ft. intervals in five borings. In the upper regions of the till (above El. 290) the required number of blows per foot ranged from 7 to 16, indicating a material of stiff consistency.[10] Below El. 290 the till has a hard consistency (25 to 40 blows per foot). Elevation 290 is the level of separation between Sunnybrook till and the lower interglacial materials.

Samples obtained from the borings were used only for identification of the soil layers. While the foundation excavation for the building was being carried out, undisturbed block and tube samples were obtained from various locations at the bottom of the excavation (El. 302). The material obtained from the excavation can be described as medium stiff grey clay till of low to medium plasticity containing a sprinkling of small stones and pebbles. The average natural water content was about 18%, the liquid limit 28%, and the plastic limit 16%. Grain-size tests showed that the material from the bottom of the excavation averaged 5% gravel size, 45% sand, 35% silt, and 15% clay size. The specific gravity of solids was 2.74.

Consolidation tests were made on specimens cut from a block sample. The relation between pressure and void ratio (Fig. 1) shows that the most probable preconsolidation pressure is 2 TSF (tons/sq/ft). The com-

Fig. 2. Front view of Mt. Sinai Hospital.

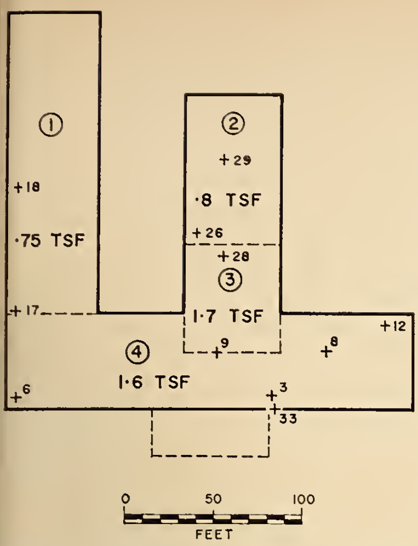


Fig. 3. Foundation plan and survey stations.

pression index is 0.14. The unconfined compression strengths of specimens cut from the same block sample average 1.7 TSF.

During the summer of 1960, D. G. Hubley, Soil Engineer, Toronto Transit Commission, kindly provided undisturbed block samples obtained in excavations in the Sunnybrook till. One block (Sample 102-3) was obtained from a depth of 25 ft. (El. 298) at a location about 100 yd. north of the hospital on University Avenue. Compression tests on specimens cut from this block are reported in Table I. Classification tests confirm that the character of the block is similar to that of the material sampled in the hospital excavation (w_L = 30, w_P = 17) but it contained fewer stones. Consolidation tests confirmed the consolidation characteristics shown in Fig. 1.

Foundation Pressures

The Mt. Sinai Hospital is a multi-storey steel frame building resting on a reinforced concrete mat. Building loads are carried to the mat through four lines of columns at 12-ft. spacing, one line at each exterior wall and one 4½ ft. from either side of the centre lines of each wing of the building. A front view of the completed building is shown in Fig. 2.

The general outline of the mat foundation is shown in Fig. 3. It is divided into four areas in which the mat thickness varies from 28 to 34 in., the total pressure on the soil varies from 0.75 to 1.7 TSF. Based on the assumption that only an average of 25% of the total design live load is active at the foundation level, less than 10% of the total pressures is due to live load. While area 1 now carries only 0.75 TSF, it is designed for an eventual height of 11 stories and a final load of 1.6 TSF.

To simplify the analysis of foundation pressures detailed consideration is given only to area 4. Except for the small difference in final total pressure, this analysis applies also to area 3 but areas 1 and 2 have much smaller foundation pressures. The effective stress at foundation level before excavation (16 ft. below original surface) was computed to be 0.8 TSF. This stress was removed during a six-week period ending April 15, 1950. During the next six months the soil was reloaded to about 0.50 TSF or to about 30% of the total building load. At this point 33 special plugs were installed in the basement columns. On October 11, 1950, the initial level survey was carried out. Stresses in the ground under the main wing (survey station 9) at various stages of construction are shown in Fig. 4. The excavation and reloading schedule of areas 3 and 4 are shown in Fig. 5.

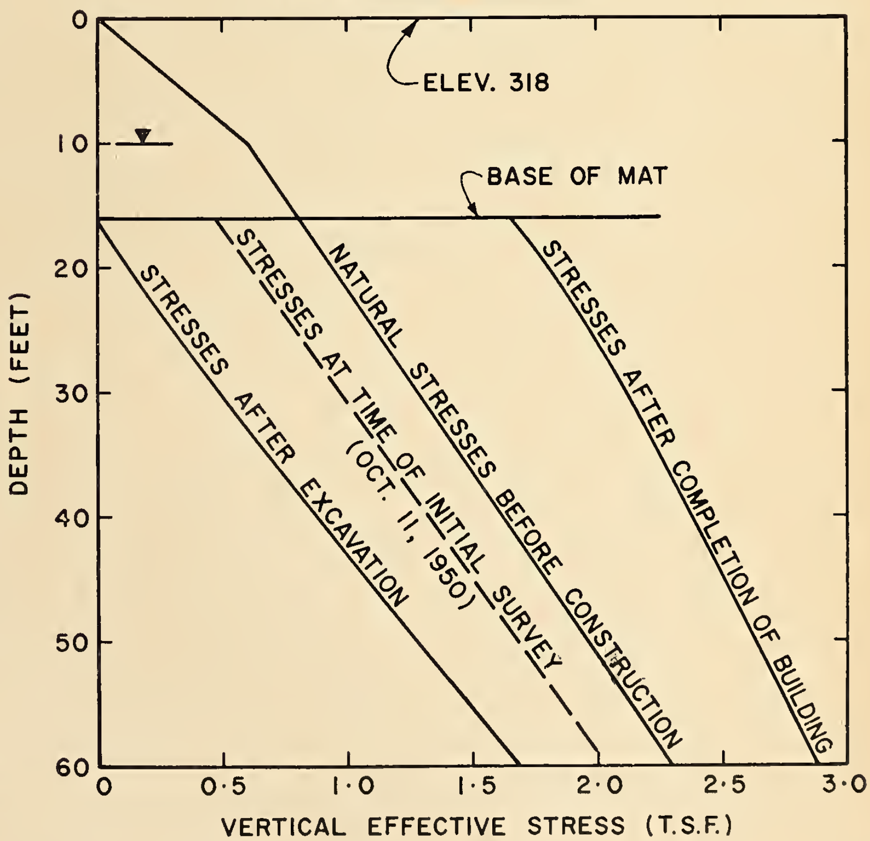
Settlement Measurements

Following the initial survey of the building in October, 1950, further surveys were made at intervals of about six months until 1954, and then again in 1956 and 1958. The interior surveys were made using a water-tube level which was patterned after an apparatus developed by Terzaghi.[9] It is described in detail by Peckover.[6] The apparatus not only has the advantage of great accuracy but also facilitates interior surveys by eliminating the need for "lines of sight." The interior surveys were related to a permanent benchmark, using an engineer's optical level. No difficulty was experienced with the water-tube surveying except that, due to the use as storage of much of area 1, it was not always possible to survey all stations or to close the survey. For other areas, an accuracy of ±0.02 in. is claimed.

After three or four years of observations, it became apparent that the total settlement of the building would be about ½ in.; considerably less than had been expected. For such a small settlement the exterior surveys were not being carried out with sufficient accuracy so it was necessary to make a special study of the probable errors. After careful study of the instrument, benchmark, and previous survey results, it was concluded that the possible error in the optical surveys might be as much as ±0.06 in. and possibly a little more when carried out under adverse weather conditions.

Since 1956, a special precise optical levelling instrument has been used and surveys were made only under ideal weather conditions. From these observations the reliability of the benchmark was definitely established.

Fig. 4. Stresses beneath station 9.



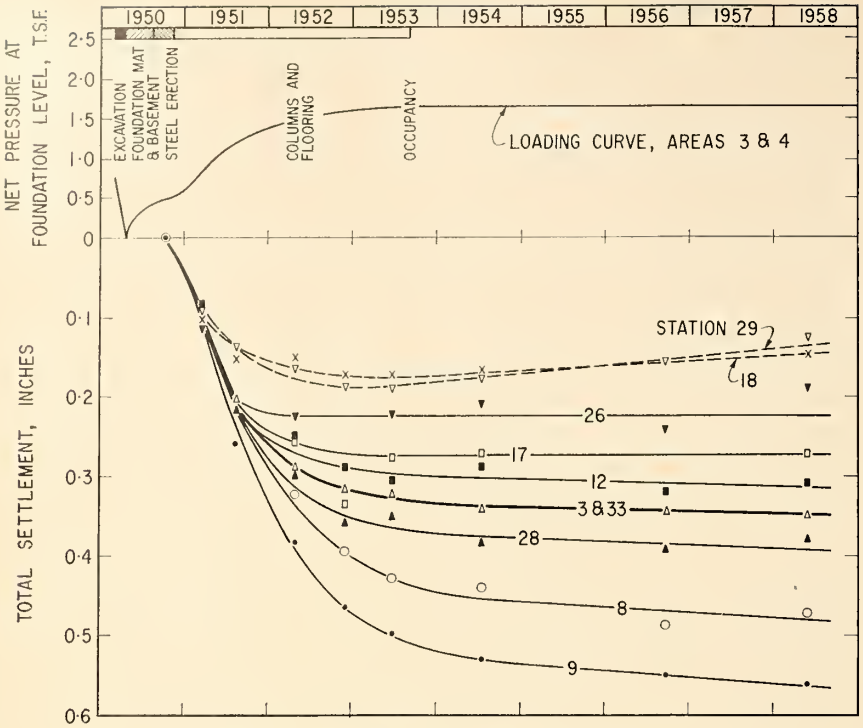


Fig. 5. Loading and settlement curves.

Because of the agreement between repeated surveys in 1956 and in 1958 the results are considered to be accurate to ±0.02 in. Outside surveys only were made in 1960 and 1961 and these, together with the surveys of 1956 and 1958, confirmed that movement of reference point 33 is practically completed.

Time-settlement curves of several typical interior stations (as located on Fig. 3) are shown on Fig. 5 together with the estimated unloading and reloading at foundation level. Settlement contours computed from the last survey are shown in Fig. 6.

Settlement Analysis

The most significant result of this study is that the measured settlement of the structure is much less than would be estimated from consolidation test results. Total settlement under the centre of the main wing of the building since the start of measurements has amounted to less than 0.6 in. The amount of rebound and recompression before measurements were begun is unknown but is considered to be small. According to the laboratory compression curve (Fig. 1) a representative sample of the subsoil would compress about 1% when loaded over a range equivalent to that from the first survey until the end of construction, i.e., 0.5 to 1.7 TSF. If an average compression of this amount occurred over a 40 ft. layer the total deflection would amount to about 5 in. Since the preconsolidation load has not been exceeded and loads were applied rather slowly it is improbable that excess pore pressures were developed with the usual time lag in deformation. There may, however, have been a plastic or secondary consolidation type of compression occurring under loads of this magnitude. Time-settlement observations (Fig. 5) tend to confirm these deductions.

Owing to the marked similarity between the shapes of the time curves of loading and of settlement (Fig. 5) it is apparent that most of the settlement is directly proportional to the applied load, and is therefore of an elastic nature. It is possible then, to compute the average modulus of elasticity of the subsoil using the classical equation:

$$E = \frac{qB(1 - \mu^2)}{\rho} I_\rho$$

where

ρ = settlement
q = increase in pressure
B = width of loaded area
μ = Poisson's ratio
E = Modulus of elasticity
I_ρ = Influence value computed by Steinbrenner.[8]

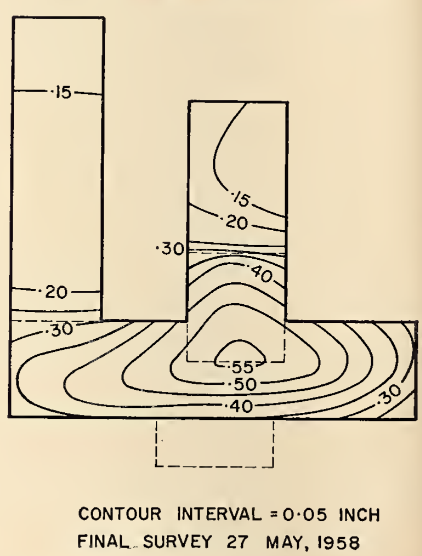
The computed modulus is affected greatly by the chosen influence value I_ρ. It, in turn, depends directly on the thickness of soil and on Poisson's ratio. The total thickness of the soil is well established but there is little doubt that the modulus of the lower Illinoian till is much greater than that of the Sunnybrook till. To estimate the modulus for the upper soil (from which laboratory results are available) it is necessary to compensate for the lower soil by using a reduced thickness of soil in the computation. To illustrate this effect, computations were made assuming soil thicknesses of 30 ft. and 40 ft.

In computing the elastic compression of a saturated soil it is commonly assumed that no volume change occurs and that Poisson's ratio equals 0.5. This is a questionable assumption because Poisson's ratio is thought to depend on the rate of loading and on the applied stress level. Therefore the modulus has been computed for various values of Poisson's ratio. These computations were checked using influence charts developed by Newmark.[5] The effect of embedment[1] was found to influence the classical case by only about 2%.

The results of these computations are shown in Table II. It is of interest to compare the modulus computed from the results of the full-scale loading with values determined from laboratory tests. The initial tangent modulus determined from the stress-strain relationships of unconfined specimens cut from the original block sample (Sample 23-5, Table I) averaged 50 TSF. The initial tangent modules for unconfined compression tests on the recently obtained sample of Sunnybrook till (Sample 102-3, Table I) averaged 130 TSF. The higher value is probably due to the lower stone content.

It has been suggested that the modulus of elasticity should be determined from the stress-strain relationships of specimens subjected to triaxial compression tests. Detailed studies have shown further improvement when axial loads are cycled.[12]

Fig. 6. Final settlement contours.



To investigate these possibilities a series of unconsolidated-undrained triaxial compression tests were made on regular specimens 1.4 in. in diameter by 3 in. high. Cell pressures were varied from foundation pressure (about 1.7 TSF) to a little more than double the applied foundation pressure. Some tests were stress cycled to deviator stresses above and below that estimated to be caused by the building, i.e., approximately 0.5 TSF. These tests revealed a wide variation in computed modulus (Table I).

This variation was largely due to the difficulty of assessing the non-linear stress-strain curves which were invariably obtained, even after cycling. The non-linearity was attributed to stones, up to ½ in. long, in the small specimens and to disturbance caused by removing small stones during trimming. In view of this a specimen 2.8 in. in diam. and 5.6 in. long was tested with a cyclical variation of axial stress from zero to a level of 0.25, 0.50 and 0.75 TSF. Fig. 7 shows some of the results. The first part of the stress-strain plot is omitted because it represents only the initial "seating in" of the specimen. To simplify the figure only a few of the typical reloading curves are shown.

Fig. 7. Stress-strain relationships for 2.8 in. diameter specimen.

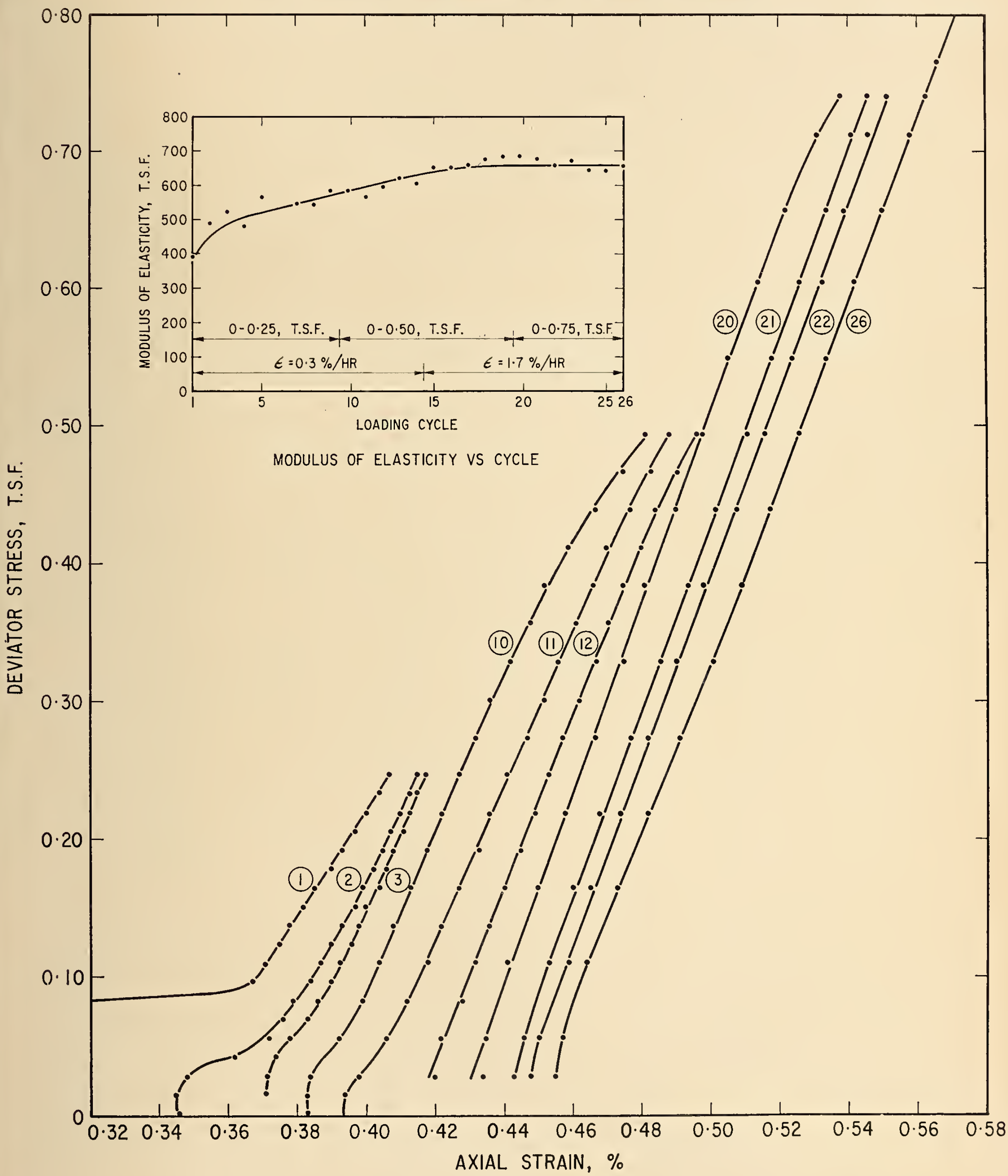


TABLE I

Compression Test Results

Sample	Water Content %	Compressive Strength TSF	Cell Pressure TSF	No. of Cycles	Maximum Axial Stress During Cycles TSF	Modulus of Elasticity, TSF		Remarks
						Range	Avg.	
Unconfined Compression Tests								
23–5	19.0	1.7	0	0		21–74	51	Avg. of 4 tests
102–3	17.8	3.3	0	0		90–160	130	Avg. of 3 tests
Unconsolidated-Undrained Compression Tests								
102–3–5	18.7	2.3	2	0			145	
–6	18.5	1.6	4	0			350	
–7	17.1	2.2	4	1	0.7		200	
				2	1.3	110–160	135	
–8	18.1	2.1	4	4	0.5	310–370	341	
				4	1.1	180–370	274	
–10	17.4	1.8	2	5	0.5	235–325	289	
–11	16.6	1.9	2	6	0.5	110–150	138	Large stone in specimen
–13	17.6	≈2.5	1.7	8	0.25	355–435	406	
				9	0.5	380–465	422	
				9	0.75	415–470	444	
–12	18.4	2.5	1.7	9	0.25	480–588	542	Large spec. (2.8″ diam.)
				10	0.5	562–685	628	
				8	0.75	641–685	664	
Consolidated-Undrained Compression Test								
–9		3.4	4	4	0.5	840–1160	965	
	16.4			4	1.1	840–980	905	

TABLE II

Computed Modulus of Elasticity of Subsoil

Depth of Layer, ft.	Modulus of Elasticity, TSF		
	$\mu = 0.5$	$\mu = 0.4$	$\mu = 0.3$
30	250	420	540
40	440	620	760

They are all of the same shape and fall more closely together with each cycle at any stress level. For simplicity, the rebound curves were also omitted. Except for the first one or two cycles at each stress level, when the loop was quite wide, the unloading curves plotted as lines almost parallel to the reloading curves and only very slightly displaced to the right of them. There was very little question about the computed value of the modulus of elasticity because most plots were straight lines and those that curved slightly had distinct straight sections. Complete destruction of the specimen, following oven drying, showed that it contained no large stones.

It was noticed that there was a tendency for the value of modulus of elasticity to increase with each stress cycle, levelling off at about 660 TSF after nearly 20 cycles (Fig. 7). This trend to increase with cycle had been noticed in similar tests on the smaller specimens. A six-fold increase in the rate of strain during cycling (Fig. 7) made no appreciable change to the test result.

A consolidated-undrained test with cycling axial stress gave a very high value for the modulus (Sample 102-3-9, Table I). This type of test is not considered to be appropriate to the problem but it has been suggested by Simons[7] that it be used, with a correction for change in water content, to arrive at a more realistic value of modulus of elasticity. This illustrates the difficulty of obtaining consistent values of a modulus which is so sensitive to slight changes in water content.

The best laboratory value for modulus of elasticity in the stress range applied by the building loads is about 600 TSF. A perfectly undisturbed specimen would be expected to give a higher value but a specimen loaded at field rates should give a lower value. Assuming these two influences to be compensating, the laboratory and field values agree reasonably well if Poisson's ratio is between 0.3 and 0.4. Agreement is poor if Poisson's ratio is assumed to be 0.5 (Table II).

Foundation Design

In selecting a mat foundation for Mt. Sinai Hospital, the designers had the benefit of the recent experience at the Hospital for Sick Children, located directly across University Avenue from the proposed site. For the Sick Children's Hospital consideration had been given to caissons, steel piles, spread footings or a mat foundation.[11] Caissons were unacceptable due to anticipated ground-water problems; piles were ruled out due to the noise of pile driving and the expected difficulty of striking large boulders in the subsoil. Both of these foundation systems were judged, in addition, to be much more costly than either a mat or spread footings.

Consideration of site conditions indicated a preference for a mat foundation rather than spread footings. Primarily it was thought desirable to distribute the building load through a relatively rigid mat in order to reduce the effects of known variations in the compressibility of the subsoil. As a result, the main wing of the Sick Children's Hospital was founded on a mat and the lighter wings were put on spread footings.

The performance of the foundation for the Mt. Sinai Hospital is illustrated by the settlement contours shown on Fig. 6. These contours are based on column deflection measurements and do not therefore give sufficient information to compute bending moments in the mat. Since the structural design of a mat is based on an estimate of the soil pressure variation that will exist under the mat and this, in turn, is dependent on the rigidity of the combined structure and mat (see for instance Grasshoff)[2] a rather large number of approximations must be made. Field measurements are required to assess the quality of the approximations. Unfortunately it is very difficult to establish instrumentation for the measurement of very slight deflections in the mat and it was not possible for this study.

The maximum measured differential column deflections may have been too small for appreciable development of the potential structural resistance to deformation. If so it might be deduced that a perfectly flexible structure would experience the same deformation. Further study along this line appears to be warranted in an effort to reduce mat thicknesses and rigidity without seriously increasing the differential settlement of the building.

Conclusions

1. A mat foundation on a subsoil typical of that under downtown Toronto is completely satisfactory.
2. The standard laboratory consolidation test considerably overestimated the settlement of a structure on this type of soil (glacial till).
3. Compression of this type of soil under the loads quoted appears to be primarily of an elastic nature.
4. The accuracy of laboratory determination of modulus of elasticity appears to be greatly increased by triaxial shear tests in which axial stress is cycled.
5. Further improvement in modulus is obtained by using larger than normal specimens.
6. The usual practice of assuming Poisson's ratio to be equal to 0.5 for saturated soils is questioned.
7. At the time of construction a mat foundation was the most economical under stated design conditions.

Acknowledgements

The authors were greatly assisted in this study by the complete cooperation of the Hospital staff and C. Hershfield of Morrison, Hershfield, Millman and Huggins, Consulting Engineers for the structural design of the hospital; they were associated with Kaplan and Sprachman the appointed architects. The installation and initial surveys were carried out by W. R. Schriever, now head of the Building Structures Section of the Division of Building Research. Special appreciation is due R. F. Legget, Director of the Division, who carried out some of the first soil studies and initiated settlement studies at the Hospital for Sick Children and at the Mt. Sinai Hospital and with whose permission this paper is published.

References

1. Fox, E. N.: **Mean Elastic Settlement of a Uniformly Loaded Area at a Depth below the Ground Surface.** Proceedings, Second International Conference on Soil Mechanics and Foundation Engineering, Vol. 1, 1948, pp. 129-132.
2. Grasshoff, H.: **Influence of Flexural Rigidity of Superstructures on the Distribution of Contact Pressure and Bending Moments of an Elastic Combined Footing.** Proceedings, Fourth International Conference on Soil Mechanics and Foundation Engineering, Vol. 1, 1957, pp. 300-306.
3. Lajtai, E. Z.: **Pleistocene Geology of the University Avenue Subway Route, Toronto,** M.A.Sc. Thesis, University of Toronto, 1961.
4. Legget, R. F. and Schriever, W. R.: **Site Investigation for Canada's First Underground Railway.** Civil Engineering and Public Works Review, Vol. 55, No. 642, 1960, pp. 73-77.
5. Newmark, Nathan M.: **Influence Charts for Computation of Vertical Displacements in Elastic Foundations.** Bulletin Number 367, 1947, University of Illinois, Engineering Experiment Station.
6. Peckover, F. L.: **A New Water Tube Level for Measuring the Settlement of Buildings.** National Research Council, Division of Building Research, Technical Paper No. 11, 1952.
7. Simons, N.: **Settlement Studies on Two Structures in Norway.** Proceedings, Fourth International Society on Soil Mechanics and Foundation Engineering, Vol. 1, 1957, pp. 431-6.
8. Steinbrenner, W.: **Tafeln zur Setzungberechnung.** Die Strasse, Vol. 1, 1934, pp. 121-124.
9. Terzaghi, K.: **Verbessertes Verfahran zur Setzungsbeobachtung.** Bautechnik, Vol. 11, 1933, pp. 579-582.
10. Terzaghi, K. and Peck, R. B.: **Soil Mechanics in Engineering Practice,** J. Wiley and Sons Inc., New York, 1948.
11. Wallace, Gordon L. and Carruthers, Clare D.: **The Hospital for Sick Children—Outline of Structure,** Journal, Royal Architectural Institute of Canada, Vol. 28, No. 6, 1951, pp. 172-3.
12. Ward, W. H., Samuels, S. G. and Butler, Muriel E.: **Further Studies of the Properties of London Clay.** Géotechnique, Vol. IX, No. 2, 1959, pp. 33-58.
13. Watt, A. K.: **Correlation of the Pleistocene Geology as Seen in the Subway with that in the Toronto Region, Canada.** Proceedings, The Geological Association of Canada, Vol. 6, Part II, 1954, pp. 69-81.

Loss Measurement in Magnetic Steel Above Saturation Density With Controlled Flux Waveform

J. S. MacKelvie,
Electrical & Electronics Engineer

H. Hollitscher,
Laboratory Engineer,

E. C. Elgar,
Mechanical Engineer,

All of the Canadian General Electric Co. Engineering Laboratory, Peterborough, Ont.

THE KNOWLEDGE of losses in electrical steel is essential in the design of electrical machines for the attainment of optimum performance, highest efficiency, lowest manufacturing cost.

The current state of this knowledge is such that a prediction of losses in specific machines is not possible without the use of empirical or "experience" factors, the adequacy of which in many cases is open to question. Total loss is known to depend on the spatial flux distribution, the rotating and oscillatory flux density components, and flux waveform. Alternatively, it can be expressed in terms of parameters describing the magnetic field strength, *H*. The inability to account completely for measured loss is due to the meagre understanding of the contribution of each of these parameters and to their variation from one design to another.

At present, the ASTM Standards on magnetic materials describe and recommend a method for loss measurement limited to an oscillatory sinusoidal flux at 10 and 15 Kilogauss peak flux density (the Epstein Method). In practice, non-sinusoidal waveforms at much higher flux densities are encountered, and frequently rotational and oscillatory magnetisation occur simultaneously. It is therefore left to the skill and experience of the design engineer and test engineer to predict and measure the actual loss in a machine.

There are three main reasons for this undesirable situation.

(1) It is difficult to manufacture economically, large quantities of electrical steel having a high degree of uniformity in magnetic properties. Variations of 5-15% in some parameters are quite normal and accepted. Steel producers therefore do not favor more detailed specifications for their products.

(2) In comparison with electrical quantities such as voltage, current and frequency, loss measurements cannot attain the same degree of accuracy. The standard methods are still subjeet to discussion, while the difficulties increase rapidly at flux densities close to and beyond saturation.

(3) There is a lack of information on the dynamic flux patterns in rotating machinery due to the difficulty of measurement. Simple search coils measure a spatial average of AC flux and do not detect DC flux. Rotating and vibratory search coils and Hall probes provide a close approximation to point measurement of both AC and DC flux, but must operate in an air gap. Furthermore, sliprings or special instruments are needed to transfer flux data generated by any transducer from a rotating member to stationary surrounding equipment.

The method of loss measurement described herein is restricted to the condition of uniform oscillatory magnetisation.

FUNCTIONAL REQUIREMENTS

The Epstein method is used primarily for quality acceptance tests. For more comprehensive loss measurements, equipment should be capable of the following functions.

(1) Magnetisation of standard test samples up to and beyond saturation in such a manner that either flux waveform or magnetic field waveform can be controlled.

(2) Measurement of loss under either of these conditions.

(3) Measurement of both peak flux density and peak magnetic field strength. Thus loss can be related to both quantities.

Several benefits accrue from equipment of this type:

(1) The data generated can more closely approximate the operating levels and conditions encountered in electrical machines.

(2) It will provide greater understanding of the dependence of loss on peak flux density, magnetic field strength and harmonics.

(3) The metallurgieal treatment and handling of steel (e.g. annealing, punching and coating) ean be modified to further minimize loss.

EQUIPMENT DESIGN

At flux densities below saturation and for sinusoidal flux, the Epstein equipment is satisfactory. At higher flux densities, problems arise that illustrate some of the difficulties associated with high flux density equipment design and have been described by Cormaek.[1] The frame can no longer produee a uniform magnetisation in the samples due to leakage flux at the corners; the flux waveform contains harmonics caused by the impedance of the supply generator and the frame; the accuraey of the Wattmeter suffers greatly due to the small phase angle between the exeitation current and the secondary frame winding voltage.

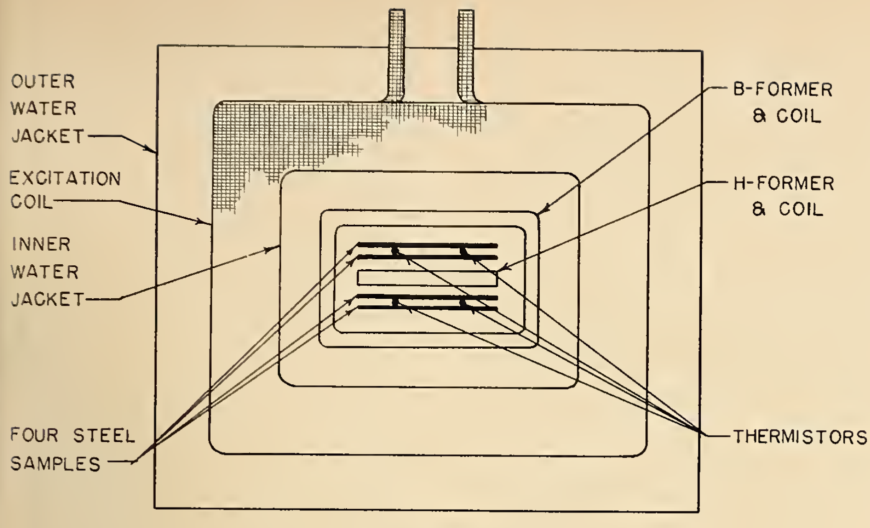
The problem of non-uniform magnetisation can be overcome with parallel-coil excitation and by measuring flux density, magnetic field strength and loss in a small region where the flux distribution is sufficiently uniform. The suppression of harmonics requires a power source specifically designed for the purpose.

SUMMARY OF EQUIPMENT FUNCTIONS

Equipment has been developed and a measurement technique established which meets the requirements already outlined.

The yoke is capable of magnetising a number of Epstein type steel samples with a peak magnetic field strength of 2500 Oe. (approx. 5000 AT/in.).

The power source can exeite the yoke to produce 2500 Oe. peak and



YOKE CROSS-SECTION

Fig. 1.

is capable of reproducing in the samples the flux and magnetic field strength waveforms experienced in eleetrical machines (fundamental frequency 30-90 c/s).

Peak flux density and peak magnetic field strength can be measured at the location of maximum uniformity.

Instrumentation enables loss to be measured calorimetrically at this same location.

With this equipment it is anticipated that loss tests can be performed on all commercially available electrical sheet steels up to and beyond saturation. The waveforms of either the flux density or magnetic field strength would be controlled within a fundamental frequency range of 30-90 c/s.

The Yoke

The yoke is designed for a maximum excitation of 2000 ampere-turns/cm. This is about eight times the maximum obtained in an Epstein frame. At this excitation all known electrical steels have reached saturation. The peak flux density in these steels will then be between 20 and 24 kilogauss, depending on the type of steel.

It was decided to use standard Epstein samples, 3 cm. by 28 cm., so that the test data would be directly comparable to Epstein data. Narrower samples could not be considered, since earlier investigation by others showed that a minimum width of 3 cm. is required to sufficiently reduce the influence of the sheared edges on the loss in the material.

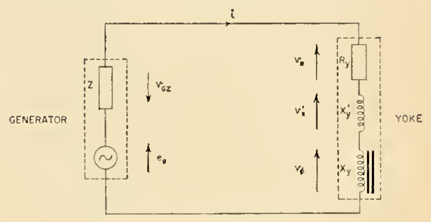
Parallel-connected coil sections were adopted as a basis for the yoke design. Since the supply voltage is applied to each section, the flux distribution becomes uniform for an appreciable distance along the axis at the centre of the yoke. To obtain a rigid coil of high thermal conductivity, a rectangular wire was used with a silica-filled epoxy brushed between layers.

Figs. 1 and 2 show a cross section and side elevation of the yoke. To dissipate the heat generated by the I^2R losses, the coil is placed in a plexiglass tank and water is pumped through a water jacket at the centre of the coil, and through the tank around the outside of the coil. The parallel connection of the seven coil sections is made inside the tank and only the two terminals appear through the lid of the tank.

The rectangular tube forming the inner wall of the water jacket accepts the test samples and serves as a coil-former for the B coil. A texolite strip, the H-coil fomer, is placed in the centre of the tube and carries two H-coils.

The return yoke, which closes the magnetic circuit, consists of interleaved U-shaped steel laminations stacked around the outside of the tank. To suppress magnetic and electrical interference in the search coil circuits, co-axial cable was used throughout.

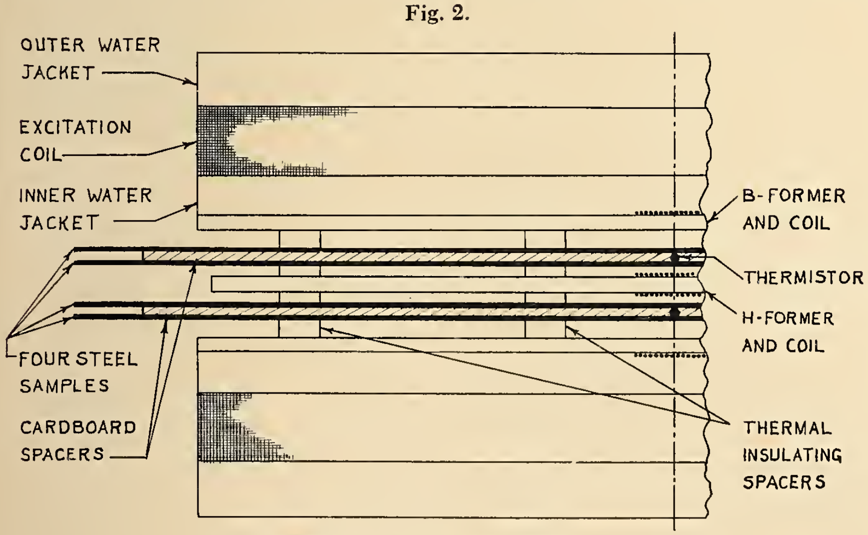
Tests on the yoke show that the flux density in the samples at 2000 ampere-turns/cm. is uniform within ±0.35% over a length of 8 cm. at the centre of the coil. Heat runs on the yoke show that the hot spot temperature at the rated current of 210 amps r.m.s. is only 75°C; at 260 amps r.m.s. the hot spot is 130°C. These measurements indicate that the yoke can produce the required uniform, high flux densities.



YOKE & GENERATOR EQUIVALENT CIRCUIT

Fig. 3.

Fig. 2.

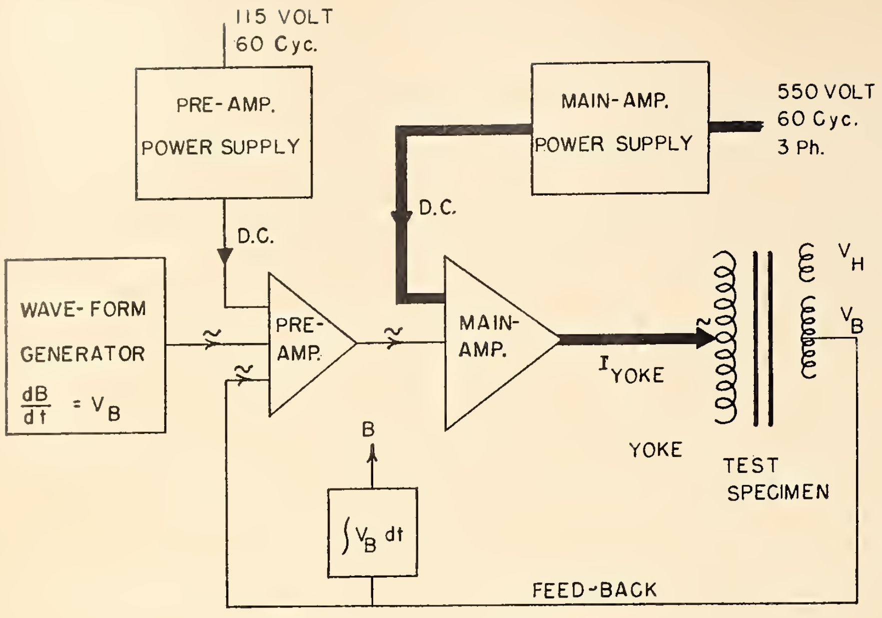


SIDE ELEVATION OF YOKE
IN SECTION

The Power Source

Flux Harmonic Generation

It is well known that harmonics are generated in the magnetic flux in the steel when the yoke is energised from a sinusoidal voltage source. At levels well below saturation, the percentage of added harmonics is negligible for loss measurement purposes and a variable frequency AC generator is adequate. At high flux densities the level of harmonics is unacceptable and a more sophisticated power source is necessary. Measurements made on an Epstein frame excited by a 12 kw. 60 c/s generator reveal the following figures for harmonic generation in motor grade steel.



POWER SOURCE WITH YOKE
(CONTROLLED FLUX WAVE-FORM)

Fig. 4.

Max. Flux Density—kg	15	18	19
Approx. kl/in^2	96	116	123
% Harmonic Generated	0.8	4	7

Harmonic generation under these circumstances has been analysed by Astbury[2] and is also described by McFarlane and Harris.[3] A brief review follows.

The equivalent circuit of a sinusoidal generator driving the yoke is shown in Fig. 3. The impedance components of the yoke are R_y, X_y, and X_y' where X_y is the reactance associated with the steel core and X_y' the leakage reactance. The internal impedance components of the generator are shown combined and of magnitude Z. For flux excursions well below the steel saturation limits, variations in X_y are negligible and the current and voltage components in the circuit are sinusoidal—in particular, $v\phi$, the voltage associated with the reactance X_y. When the steel is driven to saturation the magnitude of X_y varies widely throughout the cycle causing the waveforms of current and voltage to depart from a sine wave. Thus harmonics are generated uncontrollably in the waveform of $v\phi$, and correspondingly in the flux. It should be noted here that an attempt to lower the generator internal impedance by increasing the rating does not solve the problem entirely, since it is impossible to design a yoke where R_y and X_y' are negligible in comparison with the minimum value assumed by X_y.

Feedback Amplifiers

Feedback amplifier techniques provide an elegant means of reducing the generation of flux harmonics and have been in use for some years in steel loss measurement equipment. The theory has been presented by McFarlane and Harris.[3]

The power source described in this paper is a negative feedback amplifier specifically designed to operate the yoke. The design requirements specified were:

(1) Peak output current	300 amps.
(2) Peak output voltage	60 volts
(3) Frequency range for fundamental flux component	30-90 c/s
(4) Frequency range for harmonics	90-2000 c/s
(5) Flux distortion at maximum yoke current	5% maximum

Power Source Design

Tube-type audio amplifiers are available capable of supplying the voltage and current, provided that the yoke is properly matched. However, it is most desirable to couple the yoke directly to the amplifier; in the first place, this permits the highest degree of feedback consistent with stability; and secondly, a high quality transformer of 10 kva. rating, with a frequency response extending down to perhaps 3 c/s, is avoided. Direct coupling makes partial use of the voltage rating of any tube, and parallel operation which is necessary to extend the current rating, results in an unweildy system, uneconomical in first cost. In addition, the high instantaneous minimum plate voltage (typically 75-100 volts) results in a substantial power loss in the power source.

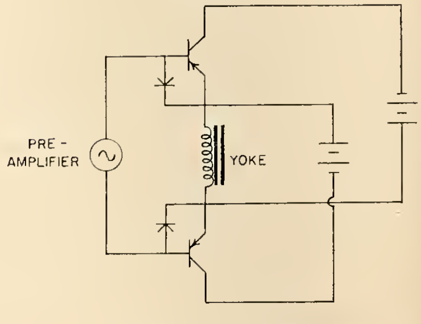
In contrast, power transistors are basically suitable for direct coupling to the yoke. These devices, when used in the Common Collector configuration, exhibit an individual output impedance of a fraction of an ohm and are available with voltage ratings up to 100 volts and current ratings up to 50 amps. The main disadvantages for this application are the limited power dissipating ability and the small band-width. Since series and parallel connections are necessary it should be mentioned that the small physical size, low eost, permanence and the freedom from auxiliary heating power are features favorable to this approach.

The block diagram of the power source, as designed, is shown in Fig. 4. High voltage-gain is achieved with a DC tube preamplifier, high current-gain with the transistor main amplifier, and voltage-to-current transformation by coupling the two with a Cathode Follower. The feedback voltage from the B-coil is returned to the preamplifier via a differential input connection. Thus the power source input signal is the time derivative of the required flux waveform.

Stability at low frequencies is ensured by using only two coupling circuits which produce phase-shift. High-frequency instability limits the loop gain and therefore the minimisation of flux harmonics. The bandwidth of the main amplifier is much less than the preamplifier or Cathode Follower and sets this limit. Fortunately, of the three alternatives the Common Collector configuration has the widest frequency band and by measurement this was found to extend to 80 kc/s. A dominant lag network is inserted in the loop to control the loop gain and phase characteristics.

Since the main amplifier is unconventional, some further detail is presented. The yoke is driven by the two halves of a Class B push-pull amplifier in a configuration which avoids a centre-tap (Fig. 5). Physically, the amplifier is distributed between four boxes, each being complete in itself as a Class B amplifier capable of supplying 75 amp. peak at 60

Fig. 5.



COMMON COLLECTOR CLASS B AMPLIFIER

volts peak. With parallel connection, 300 amp. peak is realised. Each half of each box comprises 18 transistor strings carrying 4 amps per string and parallel connected to a driver string. To meet the voltage requirement for the amplifier two transistors are series connected in each string with voltage sharing enforced by a resistor bridge. The input requirement for the amplifier is 120 mA peak and the current gain is 2500. Amplitude and phase characteristics are shown in Fig. 6.

Cooling of the transistors presents a major problem. Due to the predominantly reactive nature of the yoke impedance the input power (9 kw. max.) is almost entirely dissipated in the amplifier. The large number of transistors involved justifies an elaborate cooling system. The basic principle is presented in Fig. 7 where a jet of oil is shown projected onto the case of the transistor. The oil is then circulated through a heat exchanger.

Power Source Performance

The following measurements made at 60 c/s on motor grade steel demonstrate the effectiveness of the system in minimising flux harmonic generation. (27 db of feedback applied)

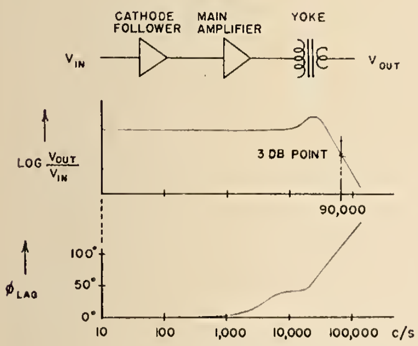
Peak Magnetic Field Strength	2500 Oe.		(5000 AT/in.)
Peak Induction	22 kg		(143 kl/in.^{2})
Harmonic Order	3	5	7 and over
% Harmonic Content	2	1	<1%

Flux Density Measurement

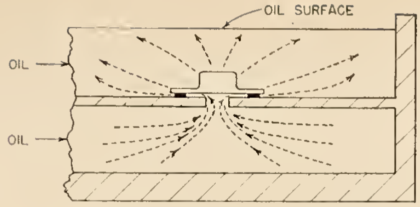
As mentioned earlier, several search coils are built into the yoke: one B-coil and two H-coils. The voltage induced in the B-coil is used for measurement of the flux density, B, and also for the feedback to the power source preamplifier. One H-coil is for direct measurement of the magnetic field strength, H, and the other for compensating the B-coil voltage for the air leakage flux.

The circuit for the search coils is shown in Fig. 8. The area turns of

Fig. 6.



MAIN AMPLIFIER FREQUENCY RESPONSE



POWER TRANSISTOR OIL COOLING TECHNIQUE

Fig. 7.

the H-compensating coil is slightly greater than that of the B-coil and the coils are connected with bucking polarity. Potentiometer R is adjusted to a permanent setting in the following manner, when the yoke is first put into use. With the wiper of potentiometer R_A set to end X, Figure 8, excitation applied, and no samples in place, the potentiometer R is adjusted to make $V_B = 0$.

When a sample is inserted in the yoke the potentiometer R_A is adjusted to reduce the bucking voltage fractionally in the ratio of the steel cross-sectional area to the B-coil area. For example, if the steel area is 10% of the B-coil area, the bucking voltage is reduced by 10% from the maximum. The voltage V_B is then the same as the voltage that would be induced in a coil wound around the samples from which air leakage flux was absent. The dial on potentiometer R_A is calibrated to read area in square centimetres. When measured with an integrating voltmeter (e.g. an average-reading vacuum tube voltmeter), this voltage is a true measure of the peak flux density in the sample, providing that odd harmonics only are present. This conditions is fulfilled when the yoke is excited solely with AC current.[4]

When both measurement and control of the magnetic field strength are desired, the voltage V_H produced by the H-coil, Fig. 8, can be used directly without any compensating circuit. The estimated accuracy of this measurement is ±2%.

Loss Measurement

Since simple electrical measurement of the loss is impractical when the steel is magnetized beyond saturation limits, a calorimetric method was devised in which the rate of heat generation due to loss was calculated from the measured rate of temperature rise.

Figs. 1 and 2 show the steel samples inserted in the window of the yoke. As indicated in Fig. 1, four samples are tested at a time: two in the top half of the window above the H-coil former, and two in the bottom half of the window below the H-coil former.

A strip of cardboard carrying two bead thermistors is sandwiched tightly between each pair of steel samples. The thermistors are connected into one arm of a simple Wheatstone bridge and the unbalanced bridge voltage recorded with a L & N Speedomax G, Model S Recorder.

Water from a reservoir is pumped through the water jacket around the window in the coil to cool the coil and to provide a constant-temperature surface in sight of the steel strips.

Before starting a loss test, the system is allowed to cool until the rate of temperature drop of the thermistors is constant. For the actual test, the cooling curve is recorded for about 10 seconds, then the excitation is applied rapidly and the heating curve recorded for an additional 10 seconds.

In Fig. 9 typical thermistor cooling and heating curves are shown as the solid lines DE and $E\ F\ G\ H$. The corresponding curves of actual steel-sample temperature are shown as the dashed lines $I\ J$ and $J\ K\ L\ M$ (in this figure the difference between steel sample and thermistor temperatures has been greatly exaggerated).

If the simple exponential curve $M\ L\ K$ is produced back to intercept the line $I\ J$ and N, the rate of heat generation per unit weight, P_c, is given by

$$P_c = c(\tan \beta_1 + \tan \beta_2) \quad (1)$$

where c is the effective specific heat of the steel samples, the thermistor, and the cardboard strip in contact with the steel. The thermistor curve $F\ G\ H$ is an exact reproduction of the steel curve $K\ L\ M$ but shifted horizontally to the right. If this curve is produced back to point P then

$$\beta_2 = \beta_4 \text{ (approx.)} \quad (2)$$

Since the thermistor and the steel samples are both cooling at a constant rate, the curves $D\ E$ and $I\ J$ are parallel straight lines and therefore

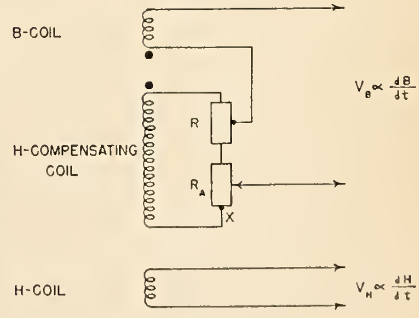
$$\beta_1 = \beta_3 \quad (3)$$

Substituting β_3 and β_4 from equations (2) and (3) into equation (1) gives

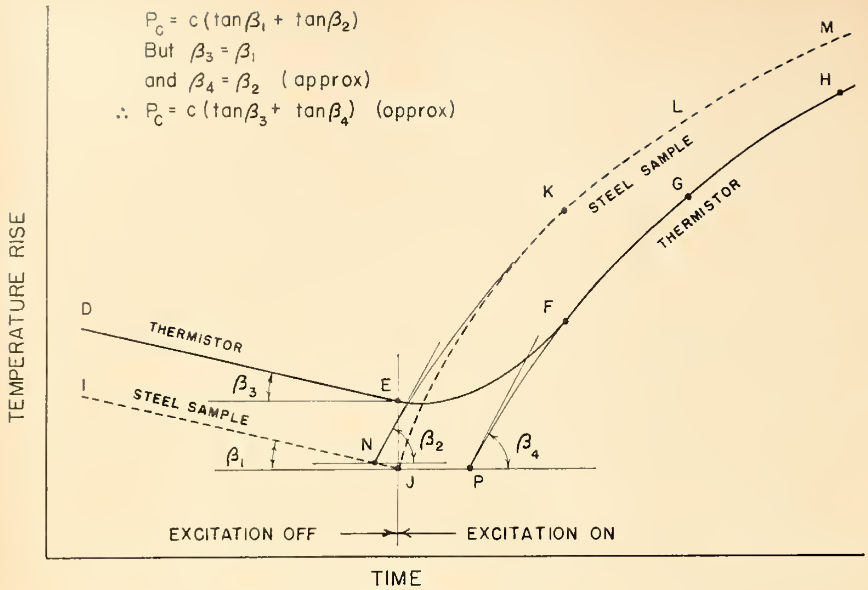
$$P_c = c(\tan \beta_3 + \tan \beta_4) \quad (4)$$

Tan β_3, the slope of the thermistor cooling curve, can easily be measured on the recorder chart. Tan β_4 is de-

Fig. 8.



SEARCH-COIL CIRCUIT



TEMPERATURE-TIME CURVES
FOR STEEL SAMPLE AND THERMISTOR

Fig. 9.

termined by fitting an exponential equation to the curve *F G H* and evaluating the derivative at point *P*.

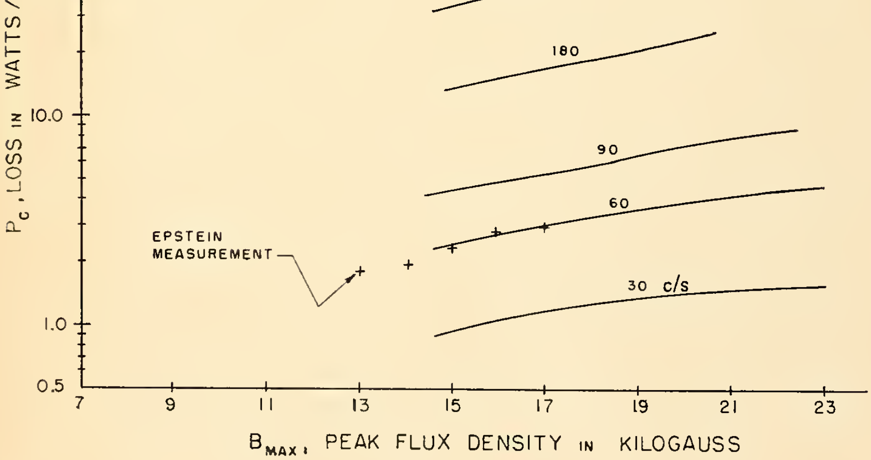
The effective specific heat, *c*, is determined by producing a known rate of heat generation in the steel by passing an electrical current through the strips and recording the cooling and heating curves in the same manner as for the loss tests. Equation (4) is then solved for the effective specific heat, *c*.

About 25 sources of error in this calorimetric determination of the loss were recognized and investigated. The apparatus, the test procedure, and the method of calculation have been carefully designed to minimize these errors. The systematic error is believed to be less than 1% and the random error less than 2% for losses in the range of 1 to 10 watts per pound.

Experimental Results

An example of the measurements obtained is given in Fig. 10. In this case samples of 25 mil motor grade steel were magnetised to produce a sinusoidal flux at frequencies ranging from 30 to 660 c/s. Due to the voltage limitation on the power source, the highest peak flux destiny that can be achieved decreases with increasing frequency.

Fig. 10.



It is not intended that high density measurement be undertaken for machine design purposes above a fundamental frequency of 90 c/s. Thus the accuracy of loss measurement above 10 watts/lb. has not been closely checked. Measurements in the range 10-100 watts/lb. are included here as an illustration of the trend in loss with increasing frequency and of the potential usefulness of the equipment for research. However, measurement accuracy in the fundamental frequency range 30-90 c/s has been carefully studied.

The results at 60 c/s have been compared with Epstein measurements over the 15-17 Kilogauss range, which is common to both equipments, and a fair agreement has been observed (Fig. 10). Apparent discrepancies can be due to a number of factors; for example:

(1) Errors exist in both methods in the determination of loss and more especially of peak flux density.

(2) The accuracy of the Epstein measurement is uncertain in its definition.

(3) One method measures loss in bulk, the other averages loss at a number of points on the samples.

General Comments

A method of loss measurement has been presented which includes a brief description of the basic equipment. Mention of the auxiliary items for signal input has so far been omitted. For sinusoidal flux, an audio signal generator is satisfactory. For studying the effect of harmonics, equipment must be available capable of generating harmonics with controlled amplitude and phase, which can then be combined with the fundamental. Again, for machine design purposes, means for observing and reproducing flux and magnetic field waveforms are required.

Improvements to the equipment might be made, such as increasing the excitation limit, reducing the time for each measurement and reducing the measurement error. This will depend on the adequacy of the information that it is capable of providing and which can only be proven in time.

References

1) Cormack, W. **The Development of a Magnetic Testing Apparatus to Determine Iron Loss at High Flux Densities** Trans. South African IEE, Oct. 1947 pp. 257-300.
2) Astbury, N. F. **Industrial Magnetic Testing** pp. 28 Bk, 1952 The Institute of Physics, London, England.
3) McFarlane, J. and Harris, M. J. **The Control of Flux Waveforms in Iron Testing by the Application of Feedback Amplifier Techniques** Proc. IEE 1958 105 Part A.
4) Astbury, op. cit. 36.

Discussion

THE PRACTICAL USE OF NON-DESTRUCTIVE TESTING AND QUALITY CONTROL FOR WELDED STEEL STRUCTURES

J. V. Hayward
Chief Welding and Quality Control Engineer, Alberta Branch,
Dominion Bridge Co. Ltd.

The Engineering Journal, August, 1962 page

Discussion by R. M. Gooderham, Manager, Canadian Welding Bureau

It is not my duty to criticize Mr. Hayward's paper and indeed I would have difficulty in doing so. In fact I am glad to associate myself with his remarks and am in general agreement with his survey, his recommendations and his strictures.

If I can serve a purpose it is perhaps to emphasize certain points which from my experience and present responsibilities seem of particular significance and importance.

Firstly, I would fully agree on the need for standards of acceptance and rejection for space frame structures. Obviously current pressure vessel standards are not necessarily applicable and indeed it is questionable if they are suited to the fields of atomic energy, modern power stations and some petro-chemical applications.

I am sure the CSA would gladly establish committees for the purpose of developing such standards if industry were to clearly signify that such was its wish. It may be hoped that Mr. Hayward's paper will further serve to focus attention to this problem and produce more concerted action so that we may have standards for each industry and, in the words of the author, "no better or no worse than needed".

I am glad to be able to report that in line with the author's thinking the CSA are presently forming a committee, at industry's request, to develop a Code for Qualification of Welding Inspectors and Organizations. This will serve to give them equal status to the fabricators whom they test and who are already qualified and certified under CSA Code W47 — "Welding Qualification Code for Application to Fabricating and Contracting Firms, Their Welding Personnel and Equipment".

Mr. Hayward has politely pointed out the limitations of radiography and ultrasonic testing and the advantages of magnetic particle especially for bridges and buildings. Equally politely I confirm and emphasize his views. In particular I would caution against too much reliance on ultrasonic in its present stage of development. It is particularly valuable as a scouting medium but indications of defects need confirmation by X-ray.

The author has proposed the qualification of welding operators by non-destructive testing and again I am glad to advise that a recent amendment to CSA Code W47 now permits this by X-ray. The Bureau in preparation for such a development has in the past made many tests by X-ray which have subsequently been confirmed by bending and thus a satisfactory correlation between the two has been developed. It is, however, significant that no such correlation has been found with the same series of tests using ultrasonic which tends to confirm the report of the author that research teams have not yet found it possible to use the amplitude of the echo on the oscillograph as a measure of defect size.

The author has properly emphasized the importance of visual inspection particularly in fit up before welding and equally during welding itself. It is an example of the economy of quality control to which he made early reference.

The author having mentioned the need for training and certifying welding inspectors could, very well I think, have proposed from his experience some means of training and perhaps he may be prevailed upon to do so. The problem is perplexing and critical to some of us.

Finally, it is my pleasure to report that an amendment to CSA Code W59 permitting 100% efficiency in welded butt joints has recently been adopted in recognition of improved weld quality and control. This is in keeping with similar revisions made some years ago in both Great Britain and the U.S.A.

Discussion by R. D. Barer, Head, Materials Engineering Pacific Naval Laboratories.

This paper is a worthwhile and comprehensive examination of the topic of non-destructive testing and quality control applied to steel weldments. I find myself in wholehearted agreement with many of the concepts and philosophies expressed by Mr. Hayward. In fact, I would like to reinforce Mr. Hayward's remarks on fabrication costs being highest where inspection and quality control are low. In our experience expensive re-working has been the result on several occasions where radiography, or other non-destructive testing control, was not used.

In Mr. Hayward's comments on the improvement in code requirements from 85% maximum weld joint efficiency to the 100% now allowed because of x-ray inspection, I would like to caution that 100% x-ray is not "per se" a guarantee of quality x-ray. And unless you attain a high level of quality in your radiographic work you can not really assess quality of a weld — you have only part of the necessary information. The qualification of radiographic personnel will undoubtedly be a major step in improving the situation. I am very pleased to see that Mr. Hayward reinforces this very point in his remarks on "Setting-up a Quality Control Program" where he points out that the value of the results obtained depend to a significant degree on the skill and experience of the technicians.

In the remarks on "Welding Code Quality Standards" based upon data related to knowledge of the effects of weld discontinuitics, I would like to point out that the technical data on which such standards can be related to the actual effect of weld discontinuities is to a large extent available in the "Proceedings of the 3rd. International Conference on NDT" held in Tokyo in March 1960.

I am inclined not to agree with Mr. Hayward that visual inspection "is in some cases the most effective form of weld inspection available today". While I agree that it is certainly useful, particularly for the checking of a fitup, I do not believe it can really be a substitute for radiography, for example. The need for a permanent record is a minor aspect of this but, more important, is the fact that we really do not know what is inside the weld except by some method such as radiography. As well as this, are the psychological benefits: when a welder knows that 100% or random samples of his work will be checked radiographically he will put in just that extra bit of care. Radiography is also useful for discussing with welding foremen and welders themselves the defects and what steps can be taken to make improvements. I would also like to emphasize the importance of radiography at the beginning of a new project (as well as follow-up checks). This is most important for the tremendous savings possible by getting a job started correctly. These last comments I notice are also very similar to ones made by Mr. Hayward in his section on "Setting-up a Quality Control Program".

I feel sure that Mr. Hayward's mention of the use of calcium tungstate screens as a means of reducing exposure times by factors as great as 100, was included primarily for completeness in his paper. In our experience we have found that it is unwise to use them for anything but the crudest of checking — in fact we have abandoned them completely. I suspect that Mr. Hayward has similar sentiments on salt screens because on reading his section "Limitations of Radiography Methods" he points out that the 2% sensitivity standard is a minimum value, and in order to detect cracks and similar fine defects techniques should be used which give the optimum in sensitivity.

I would like to emphasize and support strongly Mr. Hayward's comments regarding the loss in contrast when using isotopes as compared with x-rays. This is something that often tends to be overlooked and results, as he points out, in underestimating the severity of an observed defect.

I was interested in Mr. Hayward's remarks on the use of Caesium 137 for examining concrete both for defects and for reinforcing steel. We also had occasion a few years ago to determine the presence of reinforcing rods in concrete beams by using Cobalt 60.

I find myself in agreement on the subject of qualification of welding operators by use of non-destructive test methods as opposed to the widely used physical tests, particularly as pointed out by Mr. Hayward for "welded products which will themselves be accepted for service on results obtained by non-destructive testing examination". There is however, one caution that must be borne in mind and that is that only physical tests can really establish such things as ductility and, probably more important in some applications, the notch toughness of a welded structure. It should however be possible to establish these factors in preliminary investigations and they need not necessarily be tied in with the qualification of individual welders.

(Continued on page 56)

Month to month

UNIVERSITY REGISTRATION

A gradual decline in engineering enrolment was noted again this year in information obtained by the Institute directly from registrars.

Several highlights of this year's situation, as revealed by the E.I.C. survey, are:

Total undergraduate enrolment in Canadian engineering courses now stands at 14,390, a decrease of 500 from last year.

Engineering freshmen numbered 4,547 in the autumn of 1962, a decrease of 201 from the autumn of 1961.

The number of prospective graduates in the spring of 1963, making no allowance for wastage, is 2,316, a decrease of 274 from the previous year.

Civil, electrical and mechanical engineering remain the most popular courses. Following are the estimates of these prospective 1963 graduates, with the previous year's estimates in brackets: Civil 650 (771); Electrical 574 (643); Mechanical (505) (494).

Readers will be able to make further detailed observations by study of the tables shown on pages 49-51. If any questions should arise, E.I.C. Headquarters will gladly try to answer them.

REGIONAL INFORMATION AND CO-ORDINATION CENTRES ANOTHER E.I.C. MILESTONE

In Regina, Sask., on Saturday October 27, 1962, the first two Regional Information and Co-Ordination Centre meetings were held jointly. Attended by the two western Regional Vice-Presidents, Frank Cazalet and John Mantle, Councillors representing Branches from Victoria to Winnipeg, and Chairman of a number of Branches and Sections in Regions I and II, this highly successful meeting replaced the former Zone "A" Council meeting. President Lawton was in the Chair, and was assisted by Vice-President G. N. Martin of Montreal and the General Secretary. The consensus of all present was that the meeting was of much greater value to the Branches and to the President and Council than the previous type of meetings.

This meeting is the first of a series of Regional Information and Co-Ordination Centre meetings to be held, one in each of the ten Regions in Canada, prior to the 1963 Annual Meeting. This new activity is a result of Council's decision to initiate a regional system for improving the information and co-ordination activities within the E.I.C., and to fully develop the role of the Vice-Presidents in extending these important functions of the President. (See the Engineering Journal, November, 1962, pages 70 and 71).

During the meeting, the delegates learned at first hand of the activities of Council, and of the progress and plans of the Institute's Standing Committees. Delegates were given ample opportunity to ask for further information on many items, and to provide the President and Vice-Presidents with their thinking about E.I.C. policy and program for their guidance at meetings of Council and of the Executive Committee.

The enthusiastic reaction to this first "RI & CC" meeting is most encouraging, and augurs well for greatly improved information, communication and activity at all levels and in all areas of the E.I.C.

E.I.C. TIES

Gentlemen's neckties, bearing the E.I.C. crest and specifically designed and manufactured by experts in London, England, are now available to the membership.

They are made of either silk or Terylene, and with backgrounds of either blue or maroon.

Members wishing to purchase these handsome and unique neckties may do so by completing and returning the form below, along with their remittance to cover the cost. The regular price is $5.00, but, because of a quantity purchase they are offered at $4.00 for a limited time.

The Engineering Institute of Canada
2050 Mansfield Street
Montreal 2, Quebec

Please send me the following E.I.C. neckties, for which payment is enclosed.

	Quantity	Price
Blue silk @ $4.00	......	......
Blue Terylene @ $4.00	......	......
Red silk @ $4.00	......	......
Red Terylene @ $4.00	......	......

Date .... NAME ....
(please print)

ADDRESS ....
(please print)

....

....

COMING EVENTS

American Chemical Society. Division of Industrial and Engineering Chemistry. 29th Annual Symposium. Houston, Tex. Dec. 27-28.

Chemical Institute of Canada. Biochemistry Division. Saskatoon. January.

Society of Automotive Engineers, Inc. Annual Meeting and Engineering Display. Detroit. Jan. 14-18.

American Society for Quality Control, Institute of Radio Engineers, American Institute of Electrical Engineers. 9th National Symposium on Reliability and Quality Control. San Francisco. Jan. 22-25.

Canadian Pulp and Paper Association. Technical Section. 49th Annual Meeting. Montreal. Jan. 22-25.

American Institute of Electrical Engineers. Winter General Meeting. New York City. Jan. 27-Feb. 1.

American Society for Testing Materials. Committee Week. Montreal. Feb. 3-8.

American Society of Heating, Refrigerating and Air Conditioning Engineers. Semi-Annual Meeting. New York City. Feb. 11-14.

Continuity of E.I.C. Services

Continuity of E.I.C. services to the membership depends entirely upon the speed and accuracy with which each member responds to our requests for information.

In particular, the new publications program, which includes the provision of separate papers to those members who order one or more of the five Series of Transactions (see the Engineering Journal, November, 1962, pages 72 and 73), MAKES IT ESSENTIAL THAT THE MEMBERS COMPLETE THEIR PUBLICATIONS ORDER FORMS AND SEND IN THEIR FEES AND SUBSCRIPTIONS WITH THE MINIMUM OF DELAY.

A few months ago, we mailed a questionnaire to each recipient of the Engineering Journal, asking for personal and professional information that will help in extending E.I.C. technical services on an individual basis, and in our continuing program of improvement of E.I.C. publications.

IF YOU HAVE NOT RETURNED THIS QUESTIONNAIRE, PLEASE ASK US FOR ANOTHER AND COMPLETE AND RETURN IT WITHOUT FAIL.

THE ENGINEERING INSTITUTE OF CANADA

Officers 1962-63

PRESIDENT

F. L. Lawton, Montreal, Quebec

PAST PRESIDENTS

J. J. Hanna, Calgary
G. McK. Dick, Sherbrooke
B. G. Ballard, Ottawa

VICE-PRESIDENTS

Until May, 1963
F. M. Cazalet, Vancouver
G. N. Martin, Montreal

Until May, 1964
Paul E. Buss, Thorold
John Mantle, Saskatoon

George Humphries, London
John Waddington, Brockville
Gaetan Coté, Sherbrooke
Georges Demers, Quebec City
J. J. Rowan, Montreal
G. F. Bennett, Halifax
Stanley Carew, St. John's, Nfld.

TREASURER

A. W. Howard, Montreal

COUNCILLORS

Representing Sister Societies
E. D. Brown, Halifax
B. Chappell, Winnipeg
A. J. Groleau, Montreal
R. N. McManus, Edmonton
R. S. Sproule, Montreal

Until May, 1965
Marc Benoit, Montreal
W. L. Hutchison, Toronto
Redmond Kane, Montreal
H. A. Mullins, Montreal
C. B. Williams, Ottawa

Until May, 1964
F. Alport, Orillia
A. G. Asplin, Niagara Falls
L. A. Bateman, Winnipeg
W. A. Capelle, Ottawa
P. A. Dupuis, Quebec
F. F. Dyer, Sarnia
K. Giddings, Brampton
R. D. Hall, Lethbridge
R. J. Harvey, Montreal
W. M. Hogg, Sault Ste. Marie
D. A. Lamont, Peterborough
R. Ludwig, Saskatoon
H. A. Marshall, Halifax
T. A. Monti, Montreal
V. Palmer, Cape Breton
F. L. Perry, Calgary
J. Runge, Kitchener
A. Sandilands, Edmonton
W. M. Steeves, Moncton
J. H. Swerdfeger, Vancouver
A. M. Toye, Toronto
W. A. Wheten, Hamilton
B. T. Yates, Cornwall

Until May, 1963
V. A. Ainsworth, St. John's
Emil Bodmer, Baie Comeau
P. G. A. Brault, Montreal
H. B. Carter, Corner Brook
S. B. Cassidy, Fredericton
F. W. Catterall, Saskatoon
J. F. Chantler, Temiskaming
L. A. Coles, Summerside
A. C. Davidson, Toronto
J. E. Dykeman, Windsor
G. Flavell, Winnipeg
T. E. Flinn, Belleville
H. A. Gadd, Port Hope
H. R. Hatfield, Penticton
C. E. L. Hunt, Chalk River
W. B. Ibbotson, Sudbury
D. M. Jenkins, London
L. C. Johnson, Victoria
C. P. Jones, Vancouver
S. D. Lash, Kingston
J. Longworth, Edmonton
C. C. Louttit, Arvida
D. B. McKillop, Ft. William
J. R. Menard, Rimouski
A. S. Mitchell, Lennoxville
J. U. Moreau, Three Rivers
D. S. Moyer, Port Credit
R. A. Phillips, Montreal
W. J. Phillips, Halifax
R. W. Pryer, Sept Iles
J. W. G. Scott, Saint John
G. B. Starr, Whitehorse
R. H. Wallace, Brockville
John S. Watt, Ottawa
L. Williams, Trail
J. W. Wilson, Amherst

Ex-Officio—Chairmen of Standing Committees, who are not otherwise members of Council

J. T. Fisher, Toronto
P. W. Gooch, Montreal
W. Bruce, Montreal
E. D. Gray-Donald, Montreal

GENERAL SECRETARY

Garnet T. Page

HEADQUARTERS

2050 Mansfield Street, Montreal, Que.

EXECUTIVE COMMITTEE

Chairman: F. L. Lawton, Montreal, Que.

Members:	P. W. Gooch, Montreal
B. G. Ballard, Ottawa	E. D. Gray-Donald, Montreal
G. F. Bennett, Halifax	A. W. Howard, Montreal
Paul E. Buss, Thorold	George Humphries, London
Stanley Carew, St. John's	J. B. Mantle, Saskatoon
F. M. Cazalet, Vancouver	G. N. Martin, Montreal
Gaetan Coté, Sherbrooke	R. A. Phillips, Montreal
Georges Demers, Quebec City	J. J. Rowan, Montreal
J. T. Fisher, Toronto	John Waddington, Brockville

CHAIRMEN OF COMMITTEES

Standing Committees

Admissions: W. Bruce, Montreal
Branch Operations: E. D. Gray-Donald, Montreal
Finance: G. N. Martin, Montreal
Legislation: G. B. Williams, Ottawa
Library and House: L. J. Hamerschmid, Montreal
Membership: J. T. Fisher, Toronto
Publications: R. A. Phillips, Montreal
Technical Operations: P. W. Gooch, Montreal

Special Committees

Board of Examiners: R. Boucher, Montreal
Branch Achievement Award Selection Committee: E. D. Gray-Donald, Montreal
By-Laws: J. W. Dolphin, Kingston
Co-operative Agreements: E. D. Gray-Donald, Montreal
Institute Building Program: J. B. Stirling and R. E. Heartz, Montreal
Planning for the Future: G. McK. Dick, Sherbrooke
Editorial Review Board of Transactions: Dean D. L. Mordell, Montreal
1963 Annual Meeting Committee: J. Roy, Quebec
Professional Development Programs: W. A. Filer, Ancaster, Ont.
Prizes and Awards: B. G. Ballard, Ottawa
Student Policy: J. Hahn, Montreal

Joint Committees

Canadian I.A.E.S.T.E.: E. A. Clarke, Montreal

Trusts

Brace Bequest: D. M. Stephens, Winnipeg
Harry F. Bennett Education Fund: H. W. Umphrey, Montreal

OFFICERS OF THE BRANCHES

AMHERST
Chairman, W. D. Hagen, M.E.I.C., c/o Robb Engineering Works Ltd., Amherst, N.S.
Secretary-Treasurer, W. G. Miller, M.E.I.C., 23 Franklyn Street, Amherst, N.S.

BAIE COMEAU
Chairman, Louis Tellier, M.E.I.C., P.O. Box 575, Baie Comeau, Que.
Secretary, Douglas G. Manzer, M.E.I.C., Box 207, Site 7, R.R. 1, Hauterive, Que.

BELLEVILLE
Chairman, W. J. N. Throop, M.E.I.C., P.O. Box 305, 235 Herchimer Avenue, Belleville, Ont.
Secretary-Treasurer, E. H. Gilroy, A.M.E.I.C., 45 Prince of Wales Drive, Belleville, Ont.

BORDER CITES
Chairman, F. P. Mascarin, M.E.I.C., 1095 Croydon Road, R.R.1, Windsor, Ont.
Secretary, W. A. MacDonald, M.E.I.C., 336 Homedale Blvd., Riverside, Ont.

BRAMPTON
Chairman, Clifford L. Moon, M.E.I.C., 26 Gregory Street, Brampton, Ont.
Secretary-Treasurer, Bruce E. Wilson, M.E.I.C., 23 Hadrina Crescent, Brampton, Ont.

BROCKVILLE
Chairman, J. B. Moriarty, M.E.I.C., Benson Avenue, Cardinal, Ont.
Secretary-Treasurer, P. Stata, A.M.E.I.C., 25 Murray Street, Brockville, Ont.

CALGARY
Chairman, A. F. D. Short, M.E.I.C., 1211 - 38th Avenue S.W., Calgary.
Secretary, Ralph S. White, M.E.I.C., 660 - 97th Avenue S.E., Calgary.

CAPE BRETON
Chairman, H. C. Maitland, M.E.I.C., 39 Cross Street, Sydney, N.S.
Secretary, Lloyd R. Boutilier, M.E.I.C., 29 Royal Avenue, Sydney, N.S.

CENTRAL BRITISH COLUMBIA
Chairman, Brian S. Harvey, M.E.I.C., 1944 Abbott Street, Kelowna, B.C.
Secretary-Treasurer, R. J. Talbot, M.E.I.C., 2008 Valleyview Drive, R.R. 2, Kamloops, B.C.

CHALK RIVER
Chairman, R. Haliburton, M.E.I.C., 4 Cabot Place, Box 696, Deep River, Ontario.
Secretary, L. L. Robbins, A.M.E.I.C., 31 Glendale Ave., Deep River, Ontario.

CORNER BROOK
Chairman, W. S. Read, M.E.I.C., c/o Bowater Power & Paper, Deer Lake, Nfld.
Secretary, C. R. Newton, M.E.I.C., 7 Fern Street, Corner Brook, Nfld.

CORNWALL
Chairman, G. B. Stidwell, M.E.I.C., 416 Third Street W., Cornwall, Ont.
Secretary-Treasurer, P. L. Laprise, M.E.I.C., c/o Cornwall Street Railway Light & Power Co., 16 Second Street East, Cornwall, Ont.

EASTERN TOWNSHIPS
Chairman, Jacques Brisson, M.E.I.C., c/o Brisson & Lantendresse, P.O. Box 624, Sherbrooke, Que.
Secretary-Treasurer, P. E. Brunelle, A.M.E.I.C., 441 Blvd. Jacques Cartier N., Sherbrooke, Que.

EDMONTON
Chairman, B. A. Ellis, M.E.I.C., 12225 105 Avenue, Edmonton, Alta.
Secretary-Treasurer, D. B. Smith, M.E.I.C., 9914 - 76th Avenue, Edmonton.

FREDERICTON
Chairman, R. H. B. McLaughlin, M.E.I.C., Dept. of Civil Engineering, U. of New Brunswick, Fredericton, N.B.
Secretary, W. B. Cuthbertson, M.E.I.C., 173 Parkhurst Drive, Fredericton, N.B.

HALIFAX
Chairman, J. B. Ternan, M.E.I.C., P.O. Box 1000, Halifax.
Secretary-Treasurer, D. H. Waller, M.E.I.C., P.O. Box 33, Halifax.

HAMILTON
Chairman, W. A. H. Filer, M.E.I.C., 10 James Street N., Hamilton.
Secretary-Treasurer, K. R. Crean, M.E.I.C., Room 515, 42 James Street N., Hamilton.

HURONIA
Chairman, Frederick Alport, M.E.I.C., 65 Peter Street North, Orillia, Ont.
Secretary-Treasurer, Louis Morgante, M.E.I.C., 36 Borland Street W., Orillia, Ont.

KINGSTON
Chairman, L. C. Miller, M.E.I.C., 419 Albert Street, Kingston, Ont.
Secretary-Treasurer, F. J. Parcher, M.E.I.C., 168 Avenue Road, Kingston, Ont.

KITCHENER
Chairman, Roy Dahmer, M.E.I.C., 778 Union Street, Kitchener, Ont.
Secretary-Treasurer, E. H. Wilson, 720 Avondale Avenue, Kitchener, Ont.

KOOTENAY
Chairman, Stanley Nixon, M.E.I.C., 1530 Tulip Street, Trail, B.C.
Secretary, G. W. Downie, M.E.I.C., Box 646, Rossland, B.C.

LAKEHEAD
Chairman, L. E. Hardman, M.E.I.C., 172 Ibbottson St., Port Arthur, Ontario.
Secretary-Treasurer, J. C. Gilmore, M.E.I.C., Public Utilities Comm., Public Utilities Bldg., Port Arthur, Ont.

LETHBRIDGE
Chairman, R.N. Bower, M.E.I.C., Jefferies Concrete Prod., Box 877, Lethbridge, Alta.
Secretary-Treasurer, R. F. Smith, M.E.I.C., 2113 - 14th Avenue S., Lethbridge, Alta.

LONDON
Chairman, G. T. Fenwick, M.E.I.C., c/o Unifin Tube Co., P.O. Box 7, Clarke Side-road, London, Ont.
Secretary-Treasurer, E. Oddleifson, M.E.I.C., Hydro Electric Power Commission of Ontario, 340 Wellington Street, London, Ont.

LOWER ST. LAWRENCE
Chairman, D. F. Caveen, M.E.I.C., Notre Dame du Sacre Coeur, Rimouski, Que.
Secretary-Treasurer, Raymond Guerin, A.M.E.I.C., 1509 de la Sapiniere Street, Rimouski, Que.

MONCTON
Chairman, L. R. Wadlyn, M.E.I.C., 115 Bessborough Ave., Moncton, N.B.
Secretary-Treasurer, V. C. Blackett, M.E.I.C., 97 MacBeath Ave., Moncton, N.B.

MONTREAL
Chairman, C. Grange Kingsmill, M.E.I.C., 2050 Mansfield Street, Montreal 2.
Secretary-Treasurer, Albert Deschamps, M.E.I.C., 6931 Cote des Neiges, Montreal 26, Que.

NEWFOUNDLAND
Chairman, R. W. Myers, M.E.I.C., 123a Lemarchant Road, St. John's, Nfld.
Secretary, A. A. Andrews, A.M.E.I.C., United Town Electric, P.O. Box 1598, St. John's, Nfld.

NIAGARA PENINSULA
Chairman, G. G. Jacox, M.E.I.C., 8 Springland Gardens, Welland, Ont.
Secretary, J. F. Trant, M.E.I.C., 15 Rosewood Avenue, Welland, Ont.

NIPISSING & UPPER OTTAWA
Chairman, P. Rebin, M.E.I.C., Box 89, Sturgeon Falls, Ont.
Secretary - Treasurer, E. K. Capstick, M.E.I.C., 590 Shaw Street, North Bay, Ont.

NORTH EASTERN ONTARIO
Chairman, I. M. Foster, M.E.I.C., 6 Drury Street, Kapuskasing, Ont.
Secretary-Treasurer, John W. Shipman, M.E.I.C., 64 Dominion Street, Kapuskasing, Ont.

NORTHERN NEW BRUNSWICK
Chairman, A. L. Bond, M.E.I.C., 820 Bay Avenue, Bathurst, N.B.
Secretary-Treasurer, to be appointed.

NORTHERN NOVA SCOTIA
Chairman, J. E. Clarke, M.E.I.C., 38 Maple Avenue, New Glasgow, N.S.
Secretary, Murray C. Wolfe, M.E.I.C., P.O. Box 964, Stellarton, N.S.

NORTH SHORE LOWER ST. LAWRENCE
Chairman, B. A. Kelly, M.E.I.C., P.O. Box 188, Shelter Bay, Que.
Secretary, George Jardine, M.E.I.C., Port Cartier, Que.

OAKVILLE
Chairman, G. A. Alexander, M.E.I.C., P.O. Box 550, Oakville, Ont.
Secretary-Treasurer, R. G. Montrose, M.E.I.C., 237 Pinehurst Drive, Oakville, Ont.

OTTAWA
Chairman, Brig. A. B. Connelly, M.E.I.C., Kent-Albert Building, 150 Kent Street, Ottawa, Ont.
Secretary, James N. Pritchard, M.E.I.C., 2234 McQuaig Street, Ottawa 1.

PETERBOROUGH
Chairman, W. C. Durant, M.E.I.C., 1244 Clonsilla Avenue, Peterborough, Ont.
Secretary-Treasurer, R. H. Rehder, M.E.I.C., 14 Middleton Drive, Peterborough, Ont.

PORT CREDIT
Chairman, T. H. Rosborough, M.E.I.C., 1408 Broadmoor Avenue, Port Credit, Ont.
Secretary-Treasurer, Harry D. Smith, 790 Melton Drive, Port Credit, Ont.

PORT HOPE
Chairman, J. S. Coopman, M.E.I.C., 57 Victoria Street, Port Hope, Ont.
Secretary-Treasurer, Ross H. Abbott, M.E.I.C., Peter Street, Port Hope, Ont.

PRINCE EDWARD ISLAND
Chairman, W. S. Veale, M.E.I.C., P.O. Box 1268, Charlottetown.
Secretary-Treasurer, E. S. Chandler, M.E.I.C. 242 North River Road, R.R. 2, Charlottetown.

QUEBEC
Chairman, J. B. Delage, M.E.I.C., 2774 Montarville, Ste. Foye, Que.
Secretary-Treasurer, Jacques Plamondon, A.M.E.I.C., 14 Avenue Bon-Air, Quebec 10, Que.

RICHMOND HILL
Chairman, Kenneth Brown, M.E.I.C., 24 Idleswift Drive, Box 777, Thornhill, Ont.
Secretary-Treasurer, Jack P. Miller, M.E.I.C., 7 Sussex Avenue, Richmond Hill, Ont.

SAGUENAY
Chairman, M. Lavallee, M.E.I.C., 873 Scott Street, Chicoutimi, Que.
Secretary-Treasurer, Guy Robin, M.E.I.C., 258 St. Leon Street, Jonquiere, Que.

SAINT JOHN
Chairman, D. I. Higgins, M.E.I.C., 30 Elizabeth Court, Saint John, N.B.
Secretary-Treasurer, Eldon D. Thompson, A.M.E.I.C., P.O. Box 4, Champlain Heights, Saint John, N.B.

SAINT MAURICE VALLEY
Chairman, W. M. Ingram, M.E.I.C., P.O. Box 269, Shawinigan, Que.
Secretary, D. Irving, M.E.I.C., 1883 St. Marc Street, Shawinigan, Que.

SARNIA
Chairman, R. W. Hogson, M.E.I.C., 885 Kemsley Street, Sarnia, Ont.
Secretary-Treasurer, F. J. Routledge, M.E.I.C., 1031 Arbour Court, Sarnia, Ont.

SASKATCHEWAN
Chairman, E. J. Cole, M.E.I.C., City Engineer, Saskatoon.
Secretary-Treasurer, R. Bing-Wo, M.E.I.C., 404 McCallum Hill Bldg., Regina.

SASKATCHEWAN BRANCH SECTIONS

REGINA
Chairman, W. H. George, M.E.I.C., 41 Cardinal Crescent, Regina.
Secretary-Treasurer, E. R. Smith, M.E.I.C., 32 Dunning Crescent, Regina.

MOOSE JAW
Chairman, Flt. Lt. Vern McKinnon, M.E.I.C., 942-1st St. N.E., Moose Jaw, Saskatchewan.
Secretary-Treasurer, Gordon Skorobohach, 1194 Currie Cresc., Moose Jaw, Sask.

PRINCE ALBERT
Chairman, G. E. Baldwin, M.E.I.C., P.O. Box 1298, Prince Albert, Sask.
Secretary-Treasurer, John L. M. Scott, M.E.I.C., Box 1298, Dept. of Highways, Prince Albert, Sask.

ESTEVAN
Chairman, G. R. Ursenbach, M.E.I.C., P.O. Box 136, Estevan, Sask.
Secretary-Treasurer, G. H. Funke, A.M.E.I.C., P.O. Box 446, Estevan, Sask.

SASKATOON
Chairman, F. W. Fossey, M.E.I.C., 908 Broadway Avenue, Saskatoon.
Secretary, Prof. E. E. Brooks, M.E.I.C., 1218 Ewart Avenue, Saskatoon.

YORKTON
Chairman, D. H. Matheson, M.E.I.C., L. Matheson Bros. Ltd., Box 850, Yorkton, Sask.
Secretary, E. C. Sherwin, M.E.I.C., Municipal Roads Asst. Auth., Massey-Harris Bldg., Yorkton, Sask.

SAULT STE. MARIE
Chairman, W. B. Sproule, M.E.I.C., 167 March Street, Sault Ste. Marie, Ont.
Secretary-Treasurer, A. L. Adams, M.E.I.C., 552 Shannon Road, Sault Ste. Marie, Ont.

SUDBURY
Chairman, J. N. Raftis, M.E.I.C., Canadian General Electric Co., P.O. Box 97, Sudbury, Ont.
Secretary-Treasurer, H. S. Judges, A.M.E.I.C., Box 769, Copper Cliff, Ont.

TORONTO
Chairman, D. R. Abbey, M.E.I.C., 8 Briarfield Road, Don Mills, Ont.
Secretary-Treasurer, E. S. Bell, M.E.I.C., 6 Lakeland Crescent, Scarborough, Ont.

VANCOUVER
Chairman, D. Bakewell, M.E.I.C., 1398-20th Street, Hollyburn, B.C.
Secretary, T. Covello, M.E.I.C., 1161 Melville Street, Vancouver 5, B.C.

VANCOUVER ISLAND
Chairman, A. R. D. Robertson, M.E.I.C., 3161 Service Street, Victoria.
Secretary-Treasurer, W. Strok, M.E.I.C., 640 Queens Avenue, Victoria.

WHITBY
Chairman, To be appointed.
Secretary-Treasurer, Roy G. Beckman, M.E.I.C., 205 Bowman Avenue, P.O. Box 481, Whitby, Ont.

WINNIPEG
Chairman, R. E. Chant, M.E.I.C., Dept. of Mechanical Engineering, University of Manitoba, Fort Garry, Man.
Secretary-Treasurer, W. N. Isberg, M.E.I.C., 20 Willowridge Drive, Winnipeg 12.

YUKON
Chairman, J. E. Kellett, M.E.I.C., P.O. Box 2560, Whitehorse, Yukon.
Secretary, D. A. Whiffin, A.M.E.I.C., Northwest Highway Maintenance Est., Camp Takhini, Whitehorse, Yukon.

ONTARIO DIVISION
Chairman, Dean H. G. Conn, M.E.I.C., Queen's University, Kingston, Ont.
Secretary, A. C. Davidson, M.E.I.C., 106 Bideford Street, Downsview, Ont.

REGISTRATION IN ENGINEERING AT CANADIAN UNIVERSITIES 1962-63

University	Year	General Course	Agricultural	Petroleum	Chemical	Civil	Electrical	Industrial	Geology and Mineralogy	Mechanical	Metallurgical	Mining	Engineering Physics	Surveying	Forest	Aeronautical	Geophysical	Total
Memorial	1st	75	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	75
	2nd	55	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	55
	3rd	43	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	43
Total..........		173	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	173
Dalhousie	1st	95	...	...	...	...	...	...	...	...	...	...	5	...	...	...	...	100
	2nd	96	...	...	...	...	...	...	...	...	...	...	10	...	...	...	...	106
	3rd	27	...	...	...	...	...	...	...	...	...	...	6	...	...	...	...	33
	4th	...	...	...	...	...	...	...	...	...	...	...	3	...	...	...	...	3
	5th	...	...	...	...	...	...	...	...	...	...	...	1	...	...	...	...	1
Total..........		218	...	...	...	...	...	...	...	...	...	...	25	...	...	...	...	243
St. Mary's	1st	32	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	32
	2nd	29	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	29
	3rd	14	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	14
Total..........		75	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	75
St. Francis Xavier	1st	58	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	58
	2nd	40	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	40
	3rd	44	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	44
Total..........		142	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	142
N.S. Technical College	4th	...	...	...	20	65	48	...	...	51	4	6	...	...	...	...	...	194
	5th	...	...	...	7	56	40	...	...	37	5	4	...	...	...	...	...	149
Post-Graduates		...	...	...	3	10	8	...	...	4	...	1	...	...	...	...	...	26
Total..........		...	...	...	30	131	96	...	...	92	9	11	...	...	...	...	...	369
Acadia	1st	51	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	51
	2nd	38	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	38
	3rd	39	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	39
Total..........		128	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	128
St. Dunstan's	1st	16	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	16
	2nd	7	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	7
	3rd	7	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	7
Total..........		30	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	30
Mount Allison	1st	63	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	63
	2nd	49	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	49
	3rd	34	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	34
Total..........		146	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	146
New Brunswick	1st	...	...	...	27	39	52	...	...	17	...	3	...	3	...	...	...	141
	2nd	...	...	...	24	46	39	...	...	27	...	1	...	2	...	...	...	139
	3rd	...	...	...	7	37	46	...	...	21	...	1	...	6	...	...	...	118
	4th	...	...	...	9	45	34	...	...	20	...	...	...	4	...	...	...	112
	5th	...	...	...	7	43	22	...	...	29	...	...	...	6	...	...	...	107
Post-Graduates		...	...	...	9	15	18	...	...	3	...	...	...	3	...	...	...	48
Total..........		...	...	...	83	225	211	...	...	117	...	5	...	24	...	...	...	665
St. Joseph's	1st	21	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	21
	2nd	20	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	20
	3rd	6	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	6
Total..........		47	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	47
Laval	1st	167	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	167
	2nd	368	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	368
	3rd	...	...	...	19	42	41	...	11	29	10	3	31	...	...	...	...	186
	4th	...	...	...	11	34	42	...	3	26	9	4	16	...	...	...	...	145
	5th	...	...	...	12	43	21	...	2	23	7	2	8	...	...	...	...	118
Post-Graduates		...	...	...	5	16	19	...	14	15	6	...	...	...	...	...	...	75
Total..........		535	...	...	47	135	123	...	30	93	32	9	55	...	...	...	...	1,059
Ecole Polytechnique	1st	279	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	279
	2nd	363	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	363
	3rd	239	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	239
	4th	...	...	...	21	102	70	...	5	49	21	10	8	...	...	...	...	286
	5th	...	...	...	19	83	63	...	4	63	9	8	8	...	...	...	...	257
Post-Graduates		...	...	...	5	14	4	...	3	5	5	4	8	...	...	...	...	48
Total..........		881	...	...	45	199	137	...	12	117	35	22	24	...	...	...	...	1,472

REGISTRATION IN ENGINEERING AT CANADIAN UNIVERSITIES 1962-63

University	Year	General Course	Agricultural	Petroleum	Chemical	Civil	Electrical	Industrial	Geology and Mineralogy	Mechanical	Metallurgical	Mining	Engineering Physics	Surveying	Forest	Aeronautical	Geophysical	Total
McGill	1st	215	...	...	....	....	....	...	...	....	...	...	...	...	...	...	...	215
	2nd	197	...	...	....	....	....	...	...	....	...	...	...	...	...	...	...	197
	3rd	....	...	...	25	25	63	...	...	29	13	3	7	...	...	...	...	165
	4th	....	...	...	16	43	54	...	...	34	8	1	6	...	...	...	...	162
	5th	....	...	...	13	41	57	...	...	37	3	3	5	...	...	...	...	159
Post-Graduates		....	...	...	18	21	26	...	...	42	11	8	...	...	...	...	...	126
Total..........		412	...	...	72	130	200	...	...	142	35	15	18	...	...	...	...	1,024
Sir George Williams	1st	145	...	...	....	....	....	...	...	....	...	...	...	...	...	...	...	145
	2nd	88	...	...	....	....	....	...	...	....	...	...	...	...	...	...	...	88
	3rd	....	...	...	4	6	21	...	...	17	...	...	...	...	...	...	...	48
Total..........		233	...	...	4	6	21	...	...	17	...	...	...	...	...	...	...	281
Loyola	1st	81	...	...	....	....	....	...	...	....	...	...	...	...	...	...	...	81
	2nd	53	...	...	....	....	....	...	...	....	...	...	...	...	...	...	...	53
	3rd	....	...	...	....	11	9	...	...	15	...	...	1	...	...	...	...	36
Total..........		134	...	...	....	11	9	...	...	15	...	...	1	...	...	...	...	170
Sherbrooke	1st	67	...	...	....	....	....	...	...	....	...	...	...	...	...	...	...	67
	2nd	48	...	...	....	....	....	...	...	....	...	...	...	...	...	...	...	48
	3rd	....	...	...	....	12	13	...	...	6	...	...	...	...	...	...	...	31
	4th	....	...	...	....	12	10	...	...	9	...	...	...	...	...	...	...	31
	5th	....	...	...	....	10	11	...	...	6	...	...	...	...	...	...	...	27
Total..........		115	...	...	....	34	34	...	...	21	...	...	...	...	...	...	...	204
Ottawa	1st	109	...	...	5	5	4	...	...	3	1	...	...	...	...	...	...	127
	2nd	44	...	...	7	7	12	...	...	2	...	1	...	...	...	...	...	73
	3rd	....	...	...	8	6	17	...	...	....	...	...	...	...	...	...	...	31
	4th	....	...	...	8	....	13	...	...	....	...	...	...	...	...	...	...	21
	5th	....	...	...	5	....	17	...	...	....	...	...	...	...	...	...	...	22
Post-Graduates		....	...	...	10	....	23	...	...	....	...	...	...	...	...	...	...	33
Total..........		153	...	...	43	18	86	...	...	5	1	1	...	...	...	...	...	307
Carleton	1st	78	...	...	....	....	....	...	...	....	...	...	...	...	...	...	...	78
	2nd	34	...	...	....	....	....	...	...	....	...	...	...	...	...	...	...	34
	3rd	30	...	...	....	....	....	...	...	....	...	...	...	...	...	...	...	30
	4th	....	...	...	....	14	7	...	...	11	...	...	...	...	...	...	...	32
Post-Graduates		....	...	...	....	....	2	...	...	....	...	...	...	...	...	1	...	3
Total..........		142	...	...	....	14	9	...	...	11	...	...	...	...	...	1	...	177
Queen's	1st	252	...	...	....	....	....	...	...	....	...	...	...	...	...	...	...	252
	2nd	....	...	...	53	54	27	...	5	45	16	9	14	...	...	...	...	223
	3rd	....	...	...	20	40	26	...	1	27	14	6	22	...	...	...	...	156
	4th	....	...	...	15	32	36	...	14	26	12	7	19	...	...	...	...	161
Post-Graduates		....	...	...	8	22	17	...	6	10	3	4	4	...	...	...	...	74
Total..........		252	...	...	96	148	106	...	26	108	45	26	59	...	...	...	...	866
Toronto	1st	....	...	...	74	71	85	21	8	64	9	7	117	...	...	...	...	456
	2nd	....	...	...	55	49	57	24	6	30	14	7	69	...	...	...	...	311
	3rd	....	...	...	46	37	61	22	4	44	5	2	49	...	...	...	...	270
	4th	....	...	...	48	60	55	16	7	62	9	5	65	...	...	...	...	327
Post-Graduates		....	...	...	23	34	29	...	...	31	19	...	...	...	...	45	...	181
Total..........		....	...	...	246	251	287	83	25	231	56	21	300	...	...	45	...	1,545
McMaster	1st	92	...	...	....	....	....	...	...	....	...	...	...	...	...	...	...	92
	2nd	....	...	...	14	11	12	...	...	7	3	...	6	...	...	...	...	53
	3rd	....	...	...	9	8	17	...	...	11	1	...	2	...	...	...	...	48
	4th	....	...	...	3	5	8	...	...	7	3	...	4	...	...	...	...	30
Post-Graduates		....	...	...	11	1	1	...	...	3	1	...	...	...	...	...	...	17
Total..........		92	...	...	37	25	38	...	...	28	8	...	12	...	...	...	...	240
Ontario Agricultural College	1st	25	...	...	....	....	....	...	...	....	...	...	...	...	...	...	...	25
	2nd	19	...	...	....	....	....	...	...	....	...	...	...	...	...	...	...	19
	3rd	....	...	...	....	6	....	...	...	8	...	...	...	...	...	...	...	14
	4th	....	...	...	....	5	....	...	...	12	...	...	...	...	...	...	...	17
Post-Graduates		....	12	...	....	....	....	...	...	....	...	...	...	...	...	...	...	12
Total..........		44	12	...	....	11	....	...	...	20	...	...	...	...	...	...	...	87
Waterloo**	1st	370	...	...	....	....	....	...	...	....	...	...	...	...	...	...	...	370
	2nd	....	...	...	39	61	65	...	...	68	...	...	...	...	...	...	...	233
	3rd	....	...	...	15	27	41	...	...	40	...	...	9	...	...	...	...	132
	4th	....	...	...	13	25	29	...	...	31	...	...	13	...	...	...	...	111
	5th	....	...	...	10	28	24	...	...	27	...	...	13	...	...	...	...	102
Post-Graduates		....	...	...	3	13	13	...	...	3	...	...	...	...	...	...	...	32
Total..........		370	...	...	80	154	172	...	...	169	...	...	35	...	...	...	...	980

REGISTRATION IN ENGINEERING AT CANADIAN UNIVERSITIES 1962-63

University	Year	General Course	Agricultural	Petroleum	Chemical	Civil	Electrical	Industrial	Geology and Mineralogy	Mechanical	Metallurgical	Mining	Engineering Physics	Surveying	Forest	Aeronautical	Geophysical	Total
Western Ontario	1st	75	...	...	....	....	....	...	...	....	...	...	...	...	...	...	...	75
	2nd	55	...	...	....	....	....	...	...	....	...	...	...	...	...	...	...	55
	3rd	....	...	...	7	13	16	...	...	13	...	...	...	...	...	...	...	49
	4th	....	...	...	4	4	10	...	...	8	...	...	...	...	...	...	...	26
Post-Graduates		....	...	...	....	1	1	...	...	2	...	...	...	...	...	...	...	4
Total..........		130	...	...	11	18	27	...	...	23	...	...	...	...	...	...	...	209
Assumption	1st	18	...	...	10	12	16	...	...	10	...	...	3	...	...	...	...	69
	2nd	....	...	...	12	14	14	...	...	11	...	...	9	...	...	...	...	60
	3rd	....	...	...	5	11	19	...	...	3	...	...	4	...	...	...	...	42
	4th	....	...	...	6	9	13	...	...	5	...	...	...	...	...	...	...	33
Post-Graduates		....	...	...	5	....	2	...	...	....	...	...	...	...	...	...	...	7
Total..........		18	...	...	38	46	64	...	...	29	...	...	16	...	...	...	...	211
Laurentian	1st	3	...	...	....	....	....	...	...	....	...	...	...	...	....	...	...	3
Total..........		3	...	...	....	....	....	...	...	....	...	...	...	...	...	...	...	3
Manitoba	1st	244	...	...	....	....	....	...	...	....	...	...	...	...	...	...	...	244
	2nd	176	...	...	....	....	....	...	6	....	...	...	9	...	...	...	...	191
	3rd	....	...	...	....	52	31	...	...	31	...	...	6	...	...	...	...	120
	4th	....	...	...	....	43	45	...	1	24	...	...	3	...	...	...	...	116
Post-Graduates		....	...	...	....	37	36	...	...	9	...	...	...	...	...	...	...	82
Total..........		420	...	...	....	132	112	...	7	64	...	...	18	...	...	...	...	753
Saskatchewan	1st	312	...	...	....	....	....	...	...	....	...	...	...	...	...	...	...	312
	2nd	123	5	...	14	21	16	...	1	34	...	...	13	...	...	...	...	227
	3rd	....	7	...	15	36	54	...	11	55	...	...	10	...	...	...	...	188
	4th	....	16	...	11	66	33	...	7	48	...	1	12	...	...	...	4	198
Post-Graduates		....	8	...	4	24	11	...	8	15	...	...	13	...	...	...	...	83
Total..........		435	36	...	44	147	114	...	27	152	...	1	48	...	...	...	4	1,008
Alberta (Edmonton)	1st	220	...	...	....	....	....	...	...	....	...	...	...	...	...	...	...	220
	2nd	188	...	...	....	....	....	...	...	....	...	...	...	...	...	...	...	188
	3rd	....	...	...	39	59	66	...	...	65	9	1	4	...	...	...	...	243
	4th	....	...	9	27	64	41	...	...	34	6	3	5	...	...	...	...	189
Post-Graduates		....	...	...	23	29	15	...	...	10	...	15	...	...	...	...	...	92
Total..........		408	...	9	89	152	122	...	...	109	15	19	9	...	...	...	...	932
Alberta (Calgary)	1st	97	...	...	....	....	....	...	...	....	...	...	...	...	...	...	...	97
	2nd	74	...	...	....	....	....	...	...	....	...	...	...	...	...	...	...	74
Total..........		171	...	...	....	....	....	...	...	....	...	...	...	...	...	...	...	171
British Columbia	1st	307	...	...	....	....	....	...	...	....	...	...	...	...	...	...	...	307
	2nd	121	2	...	24	....	90	...	...	....	...	...	...	...	4	...	...	241
	3rd	....	2	...	25	43	56	...	10	54	24	2	15	...	...	...	...	231
	4th	....	...	...	26	34	52	...	9	38	19	7	9	...	2	...	...	196
Post-Graduates		....	...	...	10	23	28	...	7	8	26	...	11	...	...	...	...	113
Total..........		428	4	...	85	100	226	...	26	100	69	9	35	...	6	...	...	1,088
Canadian Services Colleges Royal Military College (Kingston)	1st	65	...	...	....	....	....	...	...	....	...	...	...	...	...	...	...	65
	2nd	36	...	...	....	....	....	...	...	....	...	...	...	...	...	...	...	36
	3rd	....	...	...	20	27	26	...	...	20	...	...	9	...	...	...	...	102
	4th	....	...	...	6	15	19	...	...	20	...	...	6	...	...	...	...	66
Total..........		101	...	...	26	42	45	...	...	40	...	...	15	...	...	...	...	269
Royal Roads	1st	130	...	...	....	....	....	...	...	....	...	...	...	...	...	...	...	130
	2nd	....	...	...	6	13	15	...	...	13	...	...	8	...	...	...	...	55
Total..........		130	...	...	6	13	15	...	...	13	...	...	8	...	...	...	...	185
College Militaire Royal de St.-Jean	1st	114	...	...	....	....	....	...	...	....	...	...	...	...	...	...	...	114
	2nd	73	...	...	....	....	....	...	...	....	...	...	...	...	...	...	...	73
Total..........		187	...	...	....	....	....	...	...	....	...	...	...	...	...	...	...	187
Grand Total		6,753	52	9	1,082	2,142	2,254	83	153	1,716	305	139	678	24	6	46	4	15,446
Post-Graduates		....	20	...	137	260	253	...	38	160	71	32	36	3	...	46	...	1,056
Prospective 1963 Graduates		....	16	9	219	650	574	16	44	505	73	40	158	6	2	...	4	2,316

**Figures shown are for the Co-operative Engineering course and represent actual enrolment in first year and combined enrolment of Fall '62 and Winter '63 (est.) for advanced years.

NOTE: LAST YEAR'S TABULATION DID *NOT* INCLUDE ANY POST-GRADUATES.

Personals

W. Buryniuk, M.E.I.C. W. Kembel, M.E.I.C.

Walter Buryniuk, M.E.I.C. (Sask. '53) and **Walter Kembel**, M.E.I.C. (Sask. '52) have become partners in the formation of Kembur Engineering Consultants. Mr. Kembel was formerly associated with Brayshaw Steel Ltd. Mr. Buryniuk was formerly with the Federal Government, C. D. Howe Co. Ltd., and Fassel Construction Ltd.

E. Rohatynski, M.E.I.C. (Manitoba '50) has been transferred as Construction Engineer IV, Kootenay Engineering Company Ltd., Kimberly Fertilizer Department of The Consolidated Mining and Smelting Company at Kimberly, B.C., from Benson Lake property following completion of construction.

B. C. Borden G. E. Purdy

Gordon E. Purdy has been appointed Eastern District Systems Engineering Manager of IBM. Mr. Purdy joined the company in 1957 as an Applied Science Trainee and has served in various systems and managerial positions in Ottawa and Montreal. **Byron C. Borden** has been appointed Manager of Product Requirements in IBM United Kingdom. Mr. Borden's appointment is a special IBM World Trade Corporation assignment. Mr. Borden joined IBM in 1956. He has a Master of Electrical Engineering degree from McGill University.

Dr. J. J. Green, M.E.I.C. (London University, Royal College of Science '39), Chief Superintendent of the Canadian Armament Research and Development Establishment, has been elected President of the Canadian Aeronautics and Space Institute.

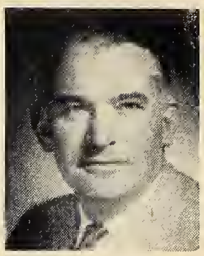
T. T. Dobie, M.E.I.C. (U.B.C. '48) has been appointed Assistant Maintenance Superintendent, Smelting Department in the Metallurgical Division of The Consolidated Mining and Smelting Company at Trail, B.C.

W. H. McCutcheon C. T. Dyment

W. H. McCutcheon has been appointed Comptroller, and **C. T. Dyment** as Works Manager at Powerlite Devices Limited. Mr. McCutcheon was formerly Manager of Purchasing and Production since joining Powerlite in 1951. Mr. Dyment has had several years' experience in industrial management and was employed as design engineer at Amalgamated Electric Corp.

Michael Rodinos, M.E.I.C. (N.S.T.C. '47) has been appointed chief engineer of the Platework Division at Dominion Bridge's Montreal Branch. Mr. Rodinos joined the company following his graduation and served as a designer in the Platework Division until 1958. In the next two years he was on loan to Atomic Energy of Canada Limited in Toronto on design work connected with the nuclear power plant project at Douglas Point, Ont.

Gordon B. Tebo, M.E.I.C. (Toronto '29) of the Canadian Standards Association Testing Laboratories, was named a Fellow of the Standards Engineers Society during the Society's Annual Meeting for his outstanding contributions to the establishment of standards, industrially, nationally, in conjunction with the United States and internationally.

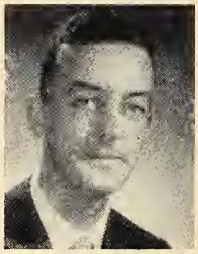


E. L. M. Gordon D. G. Currie, M.E.I.C.

D. G. Currie, M.E.I.C. (Toronto '53, Tulsa '60) has been named Assistant to the President at Bathurst Power & Paper Company Limited. Prior to this appointment, Mr. Currie was Vice-President of Sandwell and Company Limited of Vancouver.

Edward L. M. Gordon has been appointed to the staff of H. G. Acres & Company Limited, Consulting Engineers. Mr. Gordon was previously with the Federal Department of Public Works as Chief Highway Design Engineer. As Executive Engineer, he will be associated with Acres' activities in the transportation field.

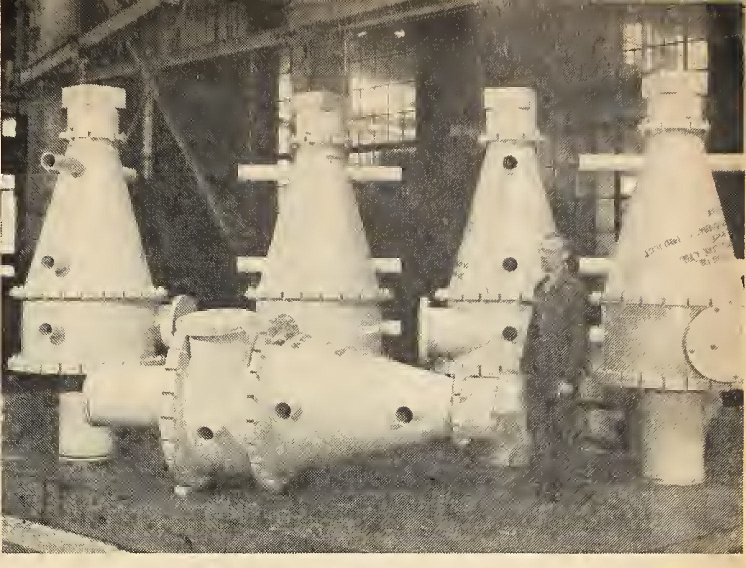
George H. Krupski, M.E.I.C. (Tech Univ. of Vienna '34) has been appointed to the Board of Directors of Brooke Bond Canada Limited. Mr. Krupski joined the company in 1950 as Plant Engineer, Montreal, and was appointed Group Factory Manager in 1961.



J. M. Bannon, M.E.I.C. G. H. Krupski, M.E.I.C.

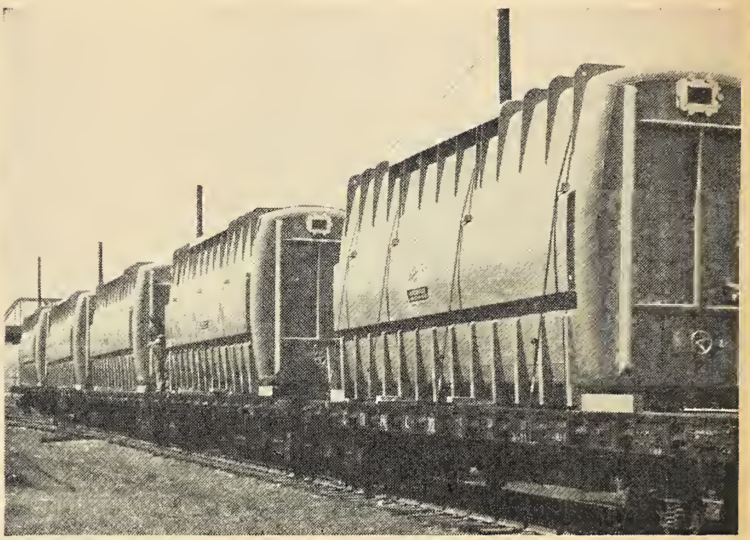
J. Mervin Bannon, M.E.I.C. (Univ. of Sydney '45) has been named General Manager, Manufacturing and Sales, at Brown Boveri (Canada) Limited. Mr. Bannon has been associated with this company for 14 years.

(Continued on page 88)

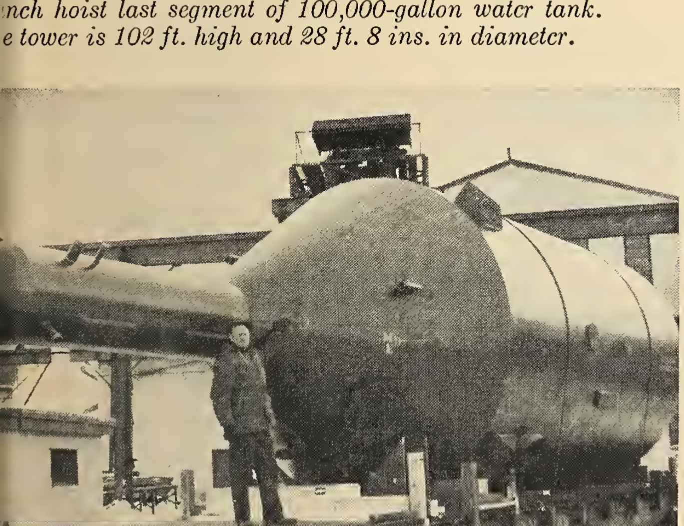


"Cyclone" thickeners for use in centrifugal separation of fine and coarse aggregates in the mining industry. Twenty-four of these 36" diameter thickeners and 60 smaller 14" diameter units were built in Montreal for Quebec Cartier Mining Company.

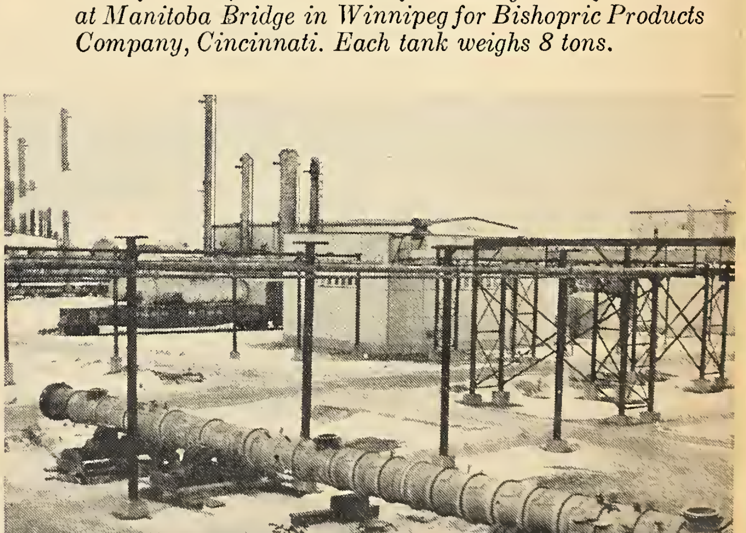
minion Bridge construction crews at our Vancouver nch hoist last segment of 100,000-gallon water tank. e tower is 102 ft. high and 28 ft. 8 ins. in diameter.



Five of nine 340-barrel closed fermenting tanks fabricated at Manitoba Bridge in Winnipeg for Bishopric Products Company, Cincinnati. Each tank weighs 8 tons.



c of 4 evaporators used in the salt industry leaving Manitoba Bridge plant in Winnipeg. Each unit is ft. in length and weighs 33 tons.



This 80-ft. long 36-inch diameter, stainless steel tower was fabricated in Edmonton for an Alberta petrochemical plant. Weight of the vessel is 22,000 pounds.

Discussion

(*Continued from page 43*)

Discussion by W. E. Havercroft,
Head, Nondestructive Testing Section
Dept. of Mines & Technical Surveys,
Ottawa.

I should like to start by presenting a direct quotation from Mr. Hayward's paper: "When a quality control program is to be set up for a large project the biggest single problem to be faced is the human element".

Mr. Hayward further indicates that inspection with high-quality non-destructive testing equipment does not assure that the quality level set for the job will be maintained, for it is necessary that skilled personnel be available to do the job. He states that education and experience are the only solution and it is on this subject that I wish to offer material for discussion.

There are very few facilities in Canada whereby knowledge in the methods of non-destructive testing can be obtained. Equipment manufacturers may present courses of instruction or some educational institutions may refer to it briefly in their technical or engineering lectures, however, most of this knowledge is gained on the job. This makes it difficult when it is desired to certify personnel for their work. It is because of this lack of proper training that certification becomes necessary. I should now like to discuss the procedure set up by the Canadian Government Specifications Board for the certification of industrial radiographers in Canada.

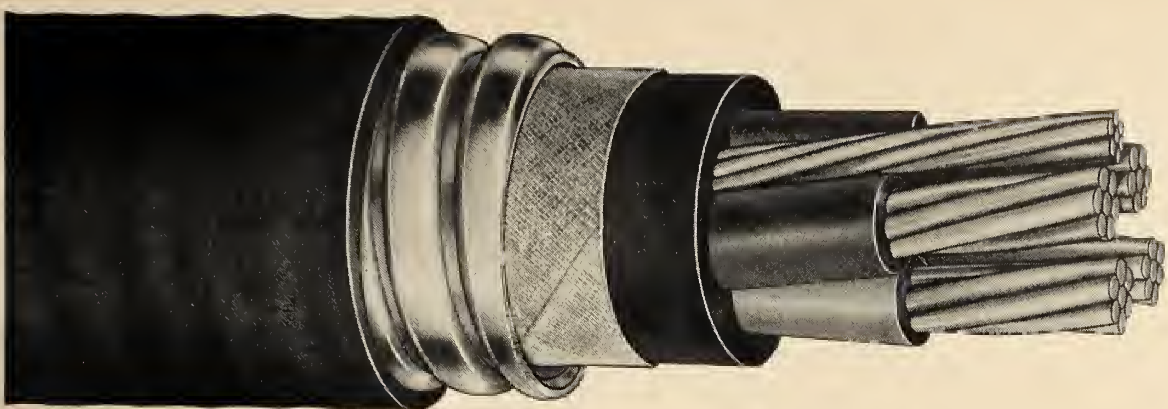
The C.G.S.B. is charged with the responsibility of preparing specifications and standards at the request of Government agencies. It does this by operating technical committees in the various commodity fields for which specifications are needed. Representation on these committees is held by interested government agencies and the main elements of the industries concerned.

A committee on industrial radiography was formed to prepare specifications for the radiography of various materials. The committee soon recognized that the lack of knowledge prevented the proper use of any specifications which might be prepared. It was felt there was a need to certify that an operator was competent, and a sub-committee on the certification of industrial radiographic personnel was formed. The object of the committee was to prepare a standard to which some agency could carry out a program of certification.

After considerable time and effort a standard for the certification of radiographic personnel No. 48-GP-4 was evolved. It was based mainly upon the R.C.A.F. system of approval of industrial radiographers which included training and testing at the Dept. of Mines & Technical Surveys in Ottawa. Upon request of the committee the Mines Branch of this department agreed to act as the examining authority.

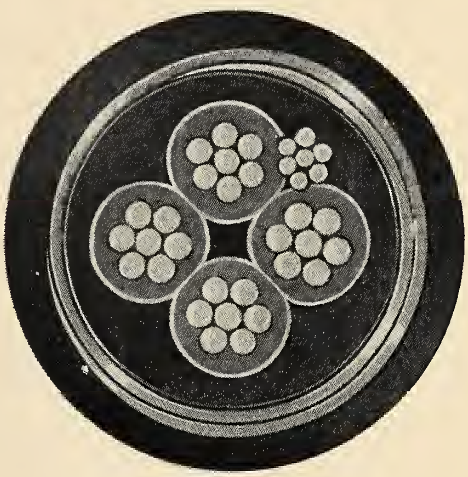
The standard, which is not mandatory, provides two categories in which personnel may be certified. These are junior and senior industrial radiographers. The main difference of these categories is that a Junior Industrial Radiographer is not responsible for establishing the manner in which a specimen should be radiographed, nor for the interpretation of the radiographic image. The Senior Industrial Radiographer is responsible for this work and capable of full supervision of a radiographic laboratory.

(*Continued on page 72*)



TECK is for the TOUGH jobs in industrial power distribution

(Here's the "inside" story)



AMPACITY

For use up to 5 kv, Teck cables meet CSA requirements for RW60 and R75; or for RW75 and R90. Can be operated at up to 90C in dry locations, 75C in wet locations.

Above 5 kv the insulation meets IPCEA specification S-19-81 for ozone-resistant butyl insulation. Can be operated at up to 85C.

CONDUCTORS

All conductors are stranded coated copper, with conductor identification by either surface colouring or coloured tapes.

Available in 2-conductor to 6-conductor configurations with built-in grounding conductor in all CSA-approved cable *at no increase in diameter.*

JACKETING

Outer jackets in either Neoprene or PVC withstand severe corrosive conditions. Both compounds are specially certified by CSA for this purpose.

The standard inner jacket is Norprene, a substance immune to high concentrations of ozone. It is flame, moisture and impact resistant. Since Norprene is not a thermoplastic, accidental exposure to high temperatures below its ignition point will not cause it to flow or melt.

An optional Butyl inner jacket is available for use where maximum heat and moisture resistance are desired.

FLEXIBLE ARMOUR

Flexible interlocked armour is normally provided in either aluminum or galvanized steel. Copper interlocked armour can be provided when requested for special applications.

SPLICING & TERMINATING

A full range of terminating and splicing fittings is available from Northern Electric. For splicing and terminating practices on the jacketed core of Teck Cable, refer to Northern Electric Engineering Instruction No. 2001—"Splicing and Termination of Norzone-Norprene Cables".

SUPPORTING & TROUGHING

Northern Electric makes available a full range of prefabricated cable troughs and supporting rack elements, in materials, finishes, sizes and accessories to meet various needs.

For full information, please refer to your nearest Northern Electric Office and request Bulletin G17-A.

3062-3

Northern Electric
COMPANY LIMITED

Branch News

BORDER CITIES
William J. Luciani

On September 7, the members of the Branch and their families were conducted on an informative tour and demonstration at the Cranbrook Institute of Science, Bloomfield Hills, Mich.

The Annual Dinner Dance was held October 26 at the Essex Golf and Country Club.

MONCTON
V. C. Blackett

On Friday, October 19, the President of the Institute addressed a combined dinner meeting of the Branch and the Amherst Branch at the Fort Cumberland Hotel, Amherst, N.S. While on route from Saint John, President and Mrs. Lawton stopped briefly in Moncton where they were entertained by the Moncton executive and their wives at a luncheon in the Brunswick Hotel. Immediately following the luncheon, President and Mrs. Lawton, accompanied by members of the Moncton Executive, proceeded to Amherst where a joint meeting of the two Branch executives was held.

CALGARY
A. F. D. Short

The Branch's first technical meeting of the 1962-63 season was held September 25 as a joint effort with the C.I.M. Mr. G. H. Thompson, President of Calgary power was the guest speaker. The title of his talk was "The Trend Toward the Use of Coal in Preference to Natural Gas in Thermo-electric Generating Stations".

The Professional Development Program, jointly sponsored by the E.I.C., A.S.P.G. and C.I.M. for the sixth year started October 3. The program, with the co-operation of the University of Alberta, is as follows: October 3, "A Survey of Canadian Economics", Lecturer — Dr. Thomas L. Powrie; October 17, "The Effect of Devaluation on the Canadian Economy", Lecturer — Dr. Frank Anton; October 31, "The European Common Market and the Canadian Economy", Lecturer — Dr. Gordon K. Goundrey; November 14, "Canada's Commitment and Responsibility to World Peace", Lecturer — R. Craig Brown; November 28, "The Development of the Canadian North", Lecturer — The Hon. Walter Dinsdale, Minister of Northern Affairs, Ottawa; December 12, "History of Southern Alberta", Lecturer — Hugh Dempsey, Archivist, Glenbow Foundation, Calgary.

The Branch holds weekly luncheon meetings every Monday at the Carolina Restaurant. Speakers and subjects during October were: October 1, "The Magic of Sulphur", a color film, courtesy of the Texas Gulf Sulphur Company; October 8, Tom Hudspeth, Backfield Coach, Calgary Stampeders, "Today We Are Top of the League"; October Professor H. R. McArthur, "Is Research for Peace Reasonable?"; October 29, Howie Thom, "Operation Design of Heat Exchangers". This weekly program continues until May. Visitors to Calgary, or residents of that city are welcome to join the Branch members at these Monday meetings.

The Branch members presented the entertainment at the banquet during the Western Zone "A" Technical Conference on September 13. The show, entitled,

(Continued on page 60)

Moncton Branch Executive, Luncheon for President and Mrs. Lawton. Front row, clockwise: Mrs. Blair; D. M. Blair; Mrs. Wadlyn; Chairman, L. R. Wadlyn; Mrs. Lawton; Mrs. Nickerson; Mrs. Hiscock; Mrs. Blackett; Councillor W. M. Steeves; Mrs. Steeves. Back row, clockwise: Vice-Chairman, J. F. Callaghan; Mrs. Callaghan; D. A. Foster; Mrs. Foster; Mrs. Dixon; H. N. Dixon; M. J. Nickerson; President F. L. Lawton; Secretary-Treasurer, V. C. Blackett; A. J. Hiscock.

A Single, Voluntary, Professional, Technical and Learned Society

Canada is indeed fortunate in having the greater part of its engineering activities concentrated within a single, voluntary, professional, technical and learned society, i.e. the Engineering Institute of Canada. The founding members of the Canadian Society of Civil Engineers, which became in 1918 the Engineering Institute of Canada, built better than they knew.

It is often said that the Canadian engineer must seek publication of his papers in the U.S.A. Founder and other societies if he is to win recognition. The evidence points, on the other hand, to the fact that, if he does seek such an outlet for papers, they become part and parcel of U.S.A. technology and tend to be accepted as such by other national communities to the detriment of Canada as a nation, to the detriment of the Canadian engineering profession, and to the detriment of Canadian economic activities abroad.

Let us look for a moment at the reality as regards the U.S.A. Founder and other societies. Springing from the original concept of engineering as military, the original Founder society was the American Society of Civil Engineers, which celebrated its centennary in 1952. Following this in rapid succession, and without regard to the chronological order in which they were formed, came the other U.S.A. Founder societies such as ASME, AIEE, AIME, AIChE, and a whole host of other societies such as IRE and smaller organizations. Initially these grew and flourished through the intensive development of their own field of technology, it responding to the rapid economic development of the U.S. and its widening swell of activities. However, it very quickly became apparent that the growth of technology was being hampered by its development within the confines of single societies. This led to joint activities between societies. An outstanding illustration of this is that AIEE finds it decidedly worthwhile and effective to sponsor either singly or jointly with one or several other societies no fewer than 60 special technical conferences. This evidence, together with a great deal of other experience, shows there is a strong trend today, and there has been for some years, to develop and establish effective contact along horizontal lines as contrasted to the vertical lines associated with development of technical activities within the confines of a single society. In fact, the evidence points strongly to possible eventual supersession of the original societies by some other arrangement. As an example, it is to be noted that ASCE, ASME, AIEE and ISA all have strong power divisions which, together, cover the complete spectrum of engineering interests in the power field. However, there are some other organizations which are definitely interested in this field too: such as ANS and even IRE in certain areas.

Having been closely associated with the technical activities of one of the American Founder societies as director of its technical operations department, I know how very fortunate we in EIC are in being able to develop within the confines of a single society all those subdivisions of the engineering discipline which are needed to meet and serve effectively the needs of our members.

Beginning in 1955, the Committee on Technical Operations (CTO) of EIC has grown from six divisions to eleven, encompassing the following:—

- Bridge and structural engineering
- Chemical engineering
- Civil engineering
- Communications, electronics and automation engineering
- Electrical engineering
- Engineering education
- Geotechnical engineering
- Hydroelectric engineering
- Management engineering
- Mechanical engineering
- Mining and metallurgical engineering

This organizational structure is not static. Engineering Divisions can be added or substracted as the need develops or, in time, possibly vanishes.

With this structure in the management of our technical activities, to best serve our members, everyone can select his field of interest and actively participate in it, either through attendance at meetings, serving on the relative Engineering Division Committee or through the presentation and discussion of papers.

Prior to the constitution of CTO in 1955, papers for annual general meetings were largely selected by a small Papers Committee revolving around Headquarters. Today, however, the Engineering Divisions of CTO, with their Canada-wide memberships, are responsible for annual general meeting technical papers of an even much higher order of technical excellence being presented, as well as for other activities closer to branch levels of activity and interest.

This effective work by the Engineering Divisions is carried out through the voluntary services of some 236 committee members who are on the alert to what is taking place in their field of technological interest, all being able engineers in their own right.

The development of the technical activities of EIC under the aegis of CTO, which acts as the coordinating group for the Engineering Divisions, is building up a Canadian engineering literature, both in the Engineering Journal and in Transactions, which is second to none. Eventually this will result in an increased acceptance of the Canadian profession as second to none in most fields of engineering activity.

F. L. Lawton, President.

Branch News

(Continued from page 58)

"Back Page Challenge", had a cast of 35 engineers and their wives. Originally produced for the Branch's Slide Rule Soiree last February, the show was suitably revised for Edmonton viewing.

CORNER BROOK

Robert G. Scott

F. Huck, Controller at Bowater's Newfoundland Pulp and Paper Mills Ltd., The Bowater Power Co. Ltd., and Bowater's Mersey Paper Co. Ltd., was guest speaker at the Branch's October 2 meeting. The topic of Mr. Huck's talk was "Responsibility Reporting". In his talk he defined this term as an accounting device aimed at increasing the efficiency in business. He said that the attitude of management today is to let a department head look after the details of running his own particular unit within the company with a minimum of interference. One of the duties of a controller is to issue regular reports to supervisors covering department costs, and efficiency. These reports enable the supervisors to judge just how well they are succeeding at their jobs and which areas are in need of improvement. Mr. Huck then explained how performance standards are established. He also discussed the method used in determining sales, production and capital budgets, both immediate and future. The many questions expressed by the members present revealed their interest in Mr. Huck's talk.

W. S. Read, Chairman of the Branch outlined the plans which the executive have for the coming year. He also gave a report on the Maritime Professional Engineers' Conference held September 6-7 at Digby Pines, N.S. An announcement was made that the President, F. L. Lawton, would not be making a visit to the Branch this year. The members present expressed their disappointment at this news. The executive for the 1962-63 session is: W. S. Read, Chairman; A. Steinberg, Vice-Chairman; R. Newton, Secretary and B. Christie, Treasurer.

HALIFAX

D. Rudolph

On October 11, the Branch held a technical meeting at Nova Scotia Technical College. The speaker for the evening was H. Headland, of Kennedy and Donkin, Consulting Engineers, London, England. Mr. Headland spoke on "Tidal Power and Pumped Storage". He outlined the history of the Seven Barrage Tidal Scheme. When planning this scheme, in 1933, it was proposed to install 72 units of 12 Mw. each. This was changed to 32 units of 25 Mw. each in 1945. Since then, no significant technical changes, other than the building of the 275 kv. grid, have taken place. The tidal characteristics of this scheme show a spring range of 47.6 feet, and a neap tide of 22.5 feet with developed power heads of 32.5 feet and 18.5 feet respectively. The peak capacity would be 800 Mw. and 600 Mw. with an operating period of 6.5 to 7.5 hours. The total yearly energy output would be approximately 2900 million kwh. The Seven Barrage Scheme is located at the mouth of a navigable river. It is a source of energy and not a firm power project. The criteria for development is based on the cost of energy delivered to the system and must not exceed the cost of generation in the most economical steam station for the same energy output. Since 1933, the coal costs have increased three times and the labour and construction material costs 2.5 times. The estimated cost of such a tidal project is $300 million. The long-term view makes the Seven Barrage Scheme justifiable as an energy producer and if construction had been undertaken in 1933, as originally planned, the project would be showing a very substantial profit.

Mr Headland then spoke on the FFESTINIOG pumped storage scheme. This project, started in 1957 is now in operation.

Mr. Headland's talks were well received. Schemes similar to the Seven Barrage type have been proposed for many years for the Halifax area. Dr. Harvey Doone thanked Mr. Headland. The meeting concluded with the 55 members enjoying coffee and doughnuts.

LAKEHEAD

Walter Buryniuk

The manager of Dominion Securities, K. Willoughby, was the guest speaker at the October 17 meeting of the Branch. In his talk on investments, Mr. Wil-

loughby outlined the studies which should be made before investing. He discussed the present economy of Canada, and presented his economic outlook. He also gave a review of the local economic picture.

A film dealing with the collapse of the United Grain Growers elevator at Port Arthur was shown November 13.

PETERBOROUGH

C. L. Willcox

On October 23 the Branch and the local chapter of the APEO held a joint meeting. C. L. Willcox, Project Engineer, Whiteshell Nuclear Project, Civilian Atomic Power Dept., Canadian General Electric Co., was the speaker. He presented a paper entitled, "Critical Path Method of Project Planning and Scheduling", in which he stated that managers are recognizing the increasing rate of growth of project-type work. Operations research has developed a method that will enable controlling project work on the exception principle. Projects are planned in detail and a model is constructed in the form of a network diagram. The longest critical path of a job is established from an analysis of this model, and a finish date for every job is scheduled. Optimum project durations can also be determined.

QUEBEC

Rene Rioux

Lundi le 10 septembre, le soleil s'est levé discrètement derrière un ciel nuageux. Une légère bruine tombait. Il n'y avait aucun doute possible, c'était bien la journée du tournoi de golf de la section de Québec de l'Institut Canadien des Ingénieurs.

Malgré la mauvaise température, les adeptes du golf se sont présentés nombreux pour participer au tournoi. La coupe Talbot pour le meilleur score brut fut remportée par M. Guy Dion et la coupe Davie pour le meilleur score net par M. Charles Rochette.

De nombreux et magnifiques prix furent distribués grâce à la générosité des nombreux amis de la section de Québec que nous tenons à remercier bien sincèrement.

Un succulent buffet fut servi et le tout se termina par une danse aux accords d'une musique dont le rythme avait peine à s'accorder avec celui des averses abondantes de l'extérieur.

Les 14 et 15 septembre avait lieu à Québec, la visite des délégués de la Conférence des Institutions d'Ingénieurs de l'Empire Britanique.

A cette occasion, la section de Québec avait organisé un programme auquel plusieurs membres ont été appelés à participer.

Parmi les manifestations signalons, vendredi, la visite du campus de l'Université Laval et du Pavillon des Sciences suivie d'une réception.

Le samedi matin, réception à l'Hôtel de Ville de Québec ou son Honneur le maire Wilfrid Hamel, après avoir fait signer le livre d'or, a souhaité la bienvenue aux délégués en leur faisant part du caractère de la Cité de Québec.

L'après-midi fut réservé pour une vicite de la Cité de Québec et ses environs.

Le soir, le conseil local de l'Institut Canadien des Ingénieurs offrait aux délégués une réception au Club de la Garnison.

Nous croyons que les délégués avec qui les ingénieurs de Québec ont fraternisé garderont un bon souvenir de leur séjour parmi nous.

WINNIPEG

Foster W. New

The Branch celebrated the 75th Anniversary of the Institute at a dinner meeting at the Town and Country Restaurant on September 27. Lee Briggs, formerly of Winnipeg, and now a member of the National Energy Board in Ottawa, was the guest speaker.

After a very pleasant dinner, Professor R. E. Chant, Chairman of the Branch, introduced members of the head table and those present at the Past Chairmans' table. L. A. Bateman then gave a short history of the Branch. He explained that he was able to compile the Branch's history despite the fact that over the years some records of the Branch had been misplaced. The Honorable Gurney Evans, Minister of Industry and Commerce, then offered the congratulations of the Manitoba Government to the Branch and to the Institute. Dr. D. M. Stephens then introduced Mr. Briggs who, in his paper, "Power for the Future", reviewed the

(Continued on page 62)

Branch News

(Continued from page 61)

changes in energy sources in Canada in the last 100 years. Mr. Briggs reviewed the present energy sourees and their costs, and discussed the problems involved in long-range forecasting of future energy requirements and sources. He pointed out that the ultimate selection of the type of energy rests with the consumer. This selection is based on economics and convenience. The energy potential in Manitoba was discussed with special reference given to the undeveloped hydro-electric capacity. Mr. Briggs pointed out that other inexpensive forms of energy are readily available in the province. In addition to the hydro potential, there are well established reserves of coal just beyond the western boundary of the province, and that local removals can be carried out by both the Inter Provincial Oil Pipe Line and Trans Canada Natural Gas Line which are carrying bulk energy to much larger markets than those in Manitoba. Methods of improved distribution of electrical energy were then reviewed. Mr. Briggs concluded his paper with a summary of the present energy situation, and an indication of future power sources which may be developed in Canada. He stated that Canadians can view with some satisfaction the potential sources of power, and the progress that has been made and which will continue to be made in the development of large quantities of power, and the controlling of costs of this power at large load centres.

WINNIPEG, Electrical Section

K. Hallson

The Electrical Section held a dinner meeting at the Marion Hotel on October 4. T. L. Woodhall, Chairman, introduced D. L. Steinberg, Assistant Area Engineer, C. N. R., and L. W. Matson, Signals Engineer, C. N. R. Mr. Matson presented introductory remarks about the new Symington Yard in St. Bonifaee.

The members then visited the C. N. R. Symington Yard where they were shown a model of the Yards. N. R. Smith, Terminal Superintendent, then presented a detailed description of the equipment and operations. A tour was then conducted through the multi-million dollar Yard, one of the most advanced push-button freight yards in the world. To reduce time of marshalling freight cars, a gravity classification system is employed to sort and service up to 6000 freight cars a day. To speed and co-ordinate operations, six systems of rapid communications are utilized by yard personnel. The systems used are radio, telephone, teletype, television, vest-pocket walkie-talkie and loud-speaker paging. Included in the Yard is a diesel shop and a car repair shop. 900 mercury-vapor floodlights provide lighting on 275 acres of the 628-acre Yard. Six miles of 24,000-volt power lines encircle the entire Yard and power sub-stations of various sizes are located within the area. EIC

Engineering Information Service

PHYSICAL PRINCIPLES AND APPLICATIONS OF JUNCTION TRANSISTORS.

Based on lectures given at McGill University to those studying for a master's degree in electrical engineering, this book is written by two members of the Radio and Electrical Engineering Division of the National Research Council in Ottawa. It commences with an outline of the principles of solid state physics required for an understanding of the main features of transistor operation. The remaining chapters in this part of the book discuss the p-n junction, the development of equivalent circuits for the transistor, transistor biasing and noise.

In the second part of the book typical circuit applications of the transistor are described, including amplifiers of various types, negative feedback, switching, oscillators and sweep generators. There are many appendices included. These are mostly devoted to detailed analyses of physical processes or circuit problems. A useful bibliography is also included. (J. H. Simpson and R. S. Richards. Toronto,

BASIC ELECTROTECHNICS, 3RD. ED.

This is the third edition of a textbook prepared by a professor of electrical engineering at the University of Cape Town. It has been expanded to include new material on electromagnetic waves and transients as well as new chapters on four-terminal network theory and electromagnetic machines. For simplicity, only M.K.S. units are used throughout. At the end of each chapter are exercises with answers, many of which were taken from the Institution of Electrical Engineering membership examination papers. (B. L. Goodlet. London, Edward Arnold, 1962. 400p., $6.30.)

IRRIGATION AND CLIMATE.

It is necessary for the engineer and agriculturist to be able to estimate and forecast agricultural water needs for various areas to ensure good crops and allow for adequate water storage. This book provides simple relationships that have been widely tested, which give reasonably consistent and reliable estimates of basic crop water requirements. The methods are of especial value in planning projects in underdeveloped countries. (Henry Oliver. London, Edward Arnold, 1961. 250p., $18.00.)

*INERTIAL GUIDANCE.

Fifteen specialists are responsible for the various aspects of the subject covered in the three main divisions of this text. The first section is devoted to a comprehensive discussion of the principal inertial sensing instruments and components of a modern inertial guidance system. The second section treats the problem of designing and mechanizing inertial navigation systems for cruise vehicles such as aircraft and marine vessels. The final section is concerned with guidance systems for rocket-propelled vehicles and space navigation. (Ed. by G. R. Pitman, Jr. New York, Wiley, 1962. 481p., $18.50.) EIC

GROUP LEADERS
RESEARCH CHEMISTS — RESEARCH ENGINEERS

The reorganization and expansion of research and development activities at Columbia Cellulose have created a number of interesting and challenging opportunities for experienced graduates holding degrees from the Bachelor to the Ph.D.

There are new openings for Group Leaders in applied research and basic studies as well as Research Chemists and Research Engineers. Experience in the fields of physical chemistry, cellulose chemistry or chemical engineering is preferred.

The Company operates two pulp mills in British Columbia producing acetate, viscose and specialty sulphite pulps and bleached kraft paper pulps. Our laboratory is one of the few in Canada offering full scope in the fields of cellulosic chemistry.

Attractive salary schedules, generous welfare plans and full moving expenses are available to the successful applicants.

Reply in confidence to:

COLUMBIA CELLULOSE
COMPANY, LIMITED

1030 West Georgia St.,
Vancouver 5, B.C.

Attention: Director of Research & Development.

ROYAL CANADIAN AIR FORCE

requires

GRADUATES IN ENGINEERING, APPLIED SCIENCE HONOURS MATHEMATICS OR PHYSICS

Employment will be initially in field or station engineering duties to assume managerial, executive and technical responsibilities. Subsequent assignments will normally involve staff, supervisory and planning duties at higher formation headquarters in Canada and overseas.

Successful applicants will be enrolled in the RCAF (Regular) with the rank of Flying Officer in one of the following technical branches commensurate with educational qualifications:

AERONAUTICAL ENGINEERING
CONSTRUCTION ENGINEERING
TELECOMMUNICATIONS

Applicants must be resident in Canada and be Canadian citizens or British subjects with the status of landed immigrant; single or married, not over 34 years of age. They may elect either a short service commission of five years duration or a permanent commission on a full time career basis.

Further details may be obtained from the nearest RCAF Recruiting Unit or by writing to:

THE DIRECTOR OF PERSONNEL MANNING
AIR FORCE HEADQUARTERS
OTTAWA, ONTARIO.

CIVIL

STRUCTURAL ENGINEER — based in Montreal. For technical services in promotion of structural steel in Quebec and Atlantic Provinces. Graduate of Canadian University desirable. Must be thoroughly bilingual. Good personality and steel design experience required. Car allowance. Annuity. Salary commensurate with ability. Send full particulars to CANADIAN INSTITUTE OF STEEL CONSTRUCTION, 338 Yonge Street, Toronto 1, Ontario.

CIVIL ENGINEER—A contracting firm specializing in the installation of caissons requires a young aggressive engineer for an opening available in the Toronto area. Candidates should be interested in the field of soil mechanics. Experience is desirable, but not necessary. Salary dependent on qualifications. Apply with full references to Personnel Manager, 7 Connie Street, Toronto 15, Ontario.

CITY ENGINEER — Applications, closing with the Town Clerk, P.O. Box 2199, Wellington, New Zealand, on Tuesday the 15th January 1963, are invited for the position of City Engineer to the Wellington City Corporation at a salary which will be fixed in the range of £NZ 3,030-£NZ 3,480 per annum. Copies of Conditions of Appointment and Schedule of Duties may be obtained from M. S. Duckworth, Town Clerk.

CIVIL ENGINEER — Required by the Corporation of The City of Windsor, Ontario. Must be capable of designing, estimating, preparing reports for sewer, pavement, and sidewalk work; supervising technical office staff. Must be a graduate of a recognized university in civil engineering; registered or capable of being registered as a Professional Engineer in the Province of Ontario; approximately 3 years' experience since graduation in municipal engineering. Fringe benefits, hospital plan, medical plan, pension, group life assurance, vacation, sick leave. Salary range $6743 to $8038 per annum. Applications by letter, together with all relevant data as to qualifications, are to be addressed to the Personnel Director, Room 304, City Hall, Windsor, Ontario. All applications will be treated as confidential.

MECHANICAL

INDUSTRIAL ENGINEER — LARGE MERCHANDISING ORGANIZATION. An excellent opportunity to join a nation-wide Company with Head Office in Toronto, requiring a graduate Engineer with a minimum of 10 years practical experience in Industrial Engineering, some part of which has been in factory management, either in a garment or automobile factory. He should have a practical knowledge of time study and motion economy and of die, jig and fixture design; as well as an understanding of standard cost accounting in addition to experience in installing and maintaining Quality Control programs. Age between 35 and 45. Starting salary will be commensurate with ability and experience. Our employee benefit program which includes a profit-sharing plan is among the best in Canada. Please submit complete resume with first reply to Department 707, Simpsons-Sears Limited, 108 Mutual Street, Toronto, Ontario.

MINING

METALLURGICAL ENGINEERS — Large progressive Corporation with subsidiary Companies in several provinces in Eastern Canada requires Metallurgical Engineers. Excellent opportunities for advancement. Reply in confidence to: File No. 292-V.

MISCELLANEOUS

ENGINEERS FOR MANAGEMENT—project, design, sales, research, development and control. Graduates of most types and ages required by clients of the Technical Service Council, a non-profit, industry-sponsored placement service. Write 2 Homewood Ave., Toronto 5, Ontario or 1500 Stanley Street, Montreal 25, Que. for an application. There is no charge for work done on your behalf. File No. 6648-V.

Graduate Mechanical Engineer

Age 35-45; for position leading to Chief Engineer for company located in New Jersey, manufacturing small high precision consumer products. Position involves responsibility in design, research and product development. Requires experience in plastic injection molding, high speed metal stamping, precision screw machine and metal finishing operations. A sound knowledge of physics essential. Some knowledge of chemistry desirable. This is a permanent, responsible and challenging position. Salary commensurate with experience.

In reply state full details of education, experience:
File No. 305-V.

Discussion

(Continued from page 56)

The standard is composed of six sections as follows:—

1. Scope.
2. Classification of Personnel.
   This defines a Junior and a Senior Industrial Radiographer.
3. Responsibilities of Personnel.
   This outlines the duties of the groups. The individual can only be examined when his duties and his level of knowledge have been established.
4. Eligibility for Certification.
   This section outlines the experience and education necessary before the certification tests may be taken.
5. Certification Procedure.
   This informs the certifying agency of the type of test to be given. A written test only for the Junior Grade candidate. A written and practical test for the Senior Grade candidate.
6. Recertification.
   This is necessary if a certified radiographer is absent for a period of one year or more from the work for which he has been certified.

A part of any test given in radiography must include the subject of radiation protection. The Radiation Protection Division of the Dept. of Health and Welfare was concerned with the preparation of the Standard. There is a separate written test on radiation protection in which the candidate must obtain a passing mark.

The Standard has been well received across Canada and has aroused considerable interest both here and in the United States. To date written tests for junior grade personnel have been conducted in Halifax, Montreal, Ottawa, Toronto, Edmonton and Vancouver. Practical tests for senior grade personnel are given only in Ottawa at the present time.

It is not desired that people should travel across Canada to Ottawa to take these tests. It is hoped eventually to obtain other facilities where they may be given. For example arrangements are being made with the Pacific Naval Laboratories in Esquimalt, B.C. to conduct senior grade examinations in the near future.

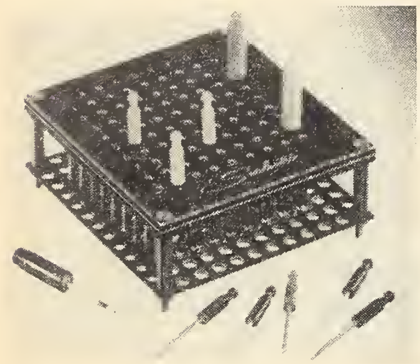
A total of 100 persons have written the junior examination. There are 10 senior certified radiographers and several others—waiting to take the tests. A suitable certificate is presented to the successful candidates.

One effect of the standard has been to arouse considerable interest in nondestructive testing in general, and in the need for courses of instruction. It appears to have awakened many groups to the fact that perhaps here is a means to enforce an increased knowledge of radiography and an improvement in quality control.

A number of institutions have conducted lectures or are planning to conduct lectures to prepare candidates for the certification

(Continued on page 84)

Industrial Briefs



Sealectoboard

THE "SEALECTOBOARD" PROTO-KIT, available from Electro Sonic Industrial Sales (Toronto) Limited, provides circuit programming without using patchcords and is used by equipment and machine tool manufacturers for economical versatile switching functions. The Sealectoboard is suited for programming of all types of electronic/electrical systems, breadboarding and anywhere else where a multiplicity of switching and circuitry changes are necessary for experimentation.

AN ELECTRO-MAGNETIC COUNTER which can be manually preset to any number between 0 and 9999 has been announced by Forster Instruments Ltd., Toronto. When pulsed, it will electrically subtract from any preset number of four figures, or less, back to zero. The model, Series 1500, has a built-in microswitch which can be made to open or close a circuit when zero is reached. The counter can then be reset to the preset number either manually or electrically, and the operation repeated. Operating speed is 20 counts per minute. Models are available to operate on 24 or 28 d.c.; 110-115 volts a.c. 50 and 60 cycles; 200-240 volts a.c. 50 cycles.

THE SHAW PROCESS, a new approach to precision casting, is described in a new 62-page booklet available from Deloro Stellite, Box 341, Belleville, Ont. Deloro Stellite is a Division of the Deloro Smelting & Refining Company, Limited.

A PRECISE RECORD of operating time for a wide range of industrial operations now can be kept with the new AC and DC running time meters manufactured by Industrial Timer Corp. and offered by Sperry Gyroscope Ottawa Limited. Each meter is a compact, ruggedly-built unit powered by a permanently lubricated synchronous motor. There are three AC models for 115 or 220 volts at 60 cps. Model C-9 covers one-tenth of an hour to 9999.9 hours, model C-9D covers one tenth of a minute to 9999.9 minutes and C-9F from one minute to 99999 minutes. The DC model, C-8 counts from one-tenth of an hour to 9999.9 hours. These meters which can be easily mounted, are powered by a solenoid wound clock movement, standard models operate on 6, 12, 28 and 32 volts.

Industrial Timer

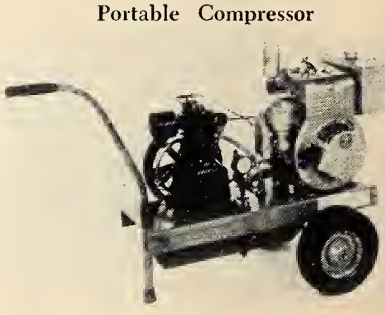
GATES RUBBER OF CANADA LTD. has developed a new three-wire-braid hydraulic hose, type 54MB. Two sizes are available ¾-inch, and one inch inside diameter. Working pressures are 4000 psi for ¾-inch hose and 3000 psi for one inch I.D. The rubber cover of this hose is highly oil-resistant and withstands abrasion, weather and sunlight. The reinforcement consists of three braids of fine steel wire, and the rubber tube gives excellent resistance against the damaging effects of hydraulic oils and fluids.

A NEW LINE of Carb-O-Lock disposable carbide inserts with built-in chip-control is available from Carboloy Section, Canadian General Electric. These chip-control inserts, are available in Carboloy cemented carbide Grades 350 and 370 for steel-cutting, applications, and Carboloy Grade 883 for applications involving non-ferrous and high temperature alloy materials. The new insert design provides a broad range of chip control in approximately 95% of all normal turning operations.

A MOLYBDENIZED LUBRICANT, Rocol Molygear, specially formulated for open gears, cams, pinions, wire ropes, draglines, chains and cables has been introduced in Canada by the Bird-Archer Co. Limited, Coburg, Ont. Molygear is said to ensure low friction and high load carrying power. It resists shock, corrosion and adhesion to moving surfaces. Since it is viscious and resilient, Molygear cushions parts and reduces noise, and being non-tacky, it resists the intrusion of dirt and foreign materials which are common problems with lubricants.

TWO HIGH-PRESSURE PORTABLE COMPRESSORS delivering 5 c.f.m. at 125 p.s.i. have been introduced by DeVilbiss (Canada) Limited. The gasoline unit, (PLE-504) has a 4½ hp. engine operating a 1½ hp. compressor. It features a recoil starter. A four-quart fuel tank ensures uninterrupted operation. The compressor can be run at lower throttle openings. The electric unit, (PL-504) has a 1½ hp. motor with on-off toggle-type switch and a 15-foot lead cord. Both units are designed for high-pressure operation with forged connection rods, precision-ground journals, drop-forged crankshaft and centrifugal force oiling to lubricate bearings internally.

Portable Compressor



• Discussion

(Continued from page 72)

examinations. The Institutes of Technology for example are becoming quite interested in the subject. Recently a one week course of instruction in radiography was sponsored in Vancouver by the British Columbia Department of Education. Its twofold purpose was to expand the knowledge of radiation protection and to prepare candidates for the certification examinations. The C.G.S.B. committee on certification is now preparing material for a series of lectures which prove useful to institutions who may wish to conduct such courses.

I have only dealt with the certification of radiographic personnel. What of certification in the other non-destructive test methods?

The C.G.S.B. has recently activated a committee on ultrasonic testing and the problem of certification of personnel will be investigated.

In the United States certification of non-destructive testing personnel is arousing much interest. A large number of industrial groups, government agencies, technical societies etc. are involved to some degree in this problem. Many groups are approving or certifying personnel within their own fields of interest and organizations such as the American Welding Society, the American Society for Testing and Materials and the Society for Nondestructive Testing feel that they must at least study the problem since it pertains to matters upon which they are well qualified to advise.

As Mr. Hayward has pointed out the use of non-destructive testing for the quality control of welded steel structures is rapidly increasing. In fact the uses and the needs for improved quality increase much faster than we can educate our operators or engineers to obtain the quality control required.

If we are to remain in step we must foster knowledge in this field. Certification of personnel is one means to provide impetus to the program.

Discussion by L. Jehu,
Welding Research & Development Engineer, Dominion Bridge Co. Ltd., Montreal.

Mr. Hayward has done an excellent job in bringing us closer to the many methods of non-destructive testing which are currently being employed in the fabricating industry. However, in dealing with such a wide subject his discussions of the various methods have necessarily been brief and in the light of current trends I feel that the discussion of ultrasonic inspection should be further explored.

Ultrasonic inspection of welds is being introduced into specifications for welded work and sometimes is being called in as an inspection tool at some stage after fabrication has commenced and it appears that, since it has the ability to indicate minute discontinuities, it is being considered as a means of guaranteeing the safety of the welded product.

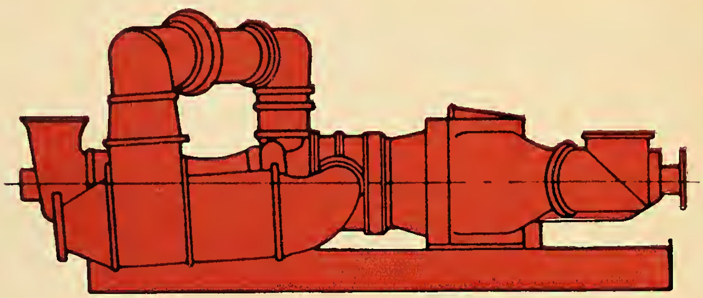
It is a simple matter to introduce a clause into a specification which merely states that "All welds shall be examined by the ultrasonic method". Once this clause has come into effect, the fabricator and inspector must receive further direction which will stipulate the conditions under which the inspection shall be done and the limits for acceptance or rejection. To the writer's

(Continued on page 86)

Canadian Oil Companies Ltd., Alberta Refinery

cut operating costs

A RUSTON TA gas-turbine will fit into your picture



Ruston TA gas turbines are cutting operating costs in the Petroleum Industry in Canada and elsewhere in the world. For instance, two TA's have been running on natural gas for more than 21,000 hours each in a Middle Eastern Oilfield Pumping Station, without a sign of deterioration of performance or need for inspection. And, due to heat and dust, working conditions have been far from ideal. Indeed, the total world wide hours of customer satisfaction substantially exceed the million mark.

The production of power . . . and heat . . . from natural gas, distillates or selected crudes, make Ruston TA gas turbines economical, highly versatile and by far the wisest choice of engineers for a variety of refinery or petrochemical applications. Ask your Ruston & Hornsby engineer to show you how a TA will fit into your picture to cut operating costs.

Ruston TA Gas Turbines—lightweight, longlife power units which give 1260 B.H.P. at the push of a button—and regularly over 10,000 hours between inspections.

RUSTON POWER PAXMAN

RUSTON & HORNSBY LTD. *associated with* **DAVEY, PAXMAN & CO. LTD.**

DISTRIBUTORS: Newfoundland: Steers Ltd., St. John's • **Nova Scotia:** Atlantic Bridge Co. Ltd., Lunenburg • **Eastern Ontario:** Ruston & Hornsby Ltd., Toronto **Quebec & New Brunswick:** Ruston & Hornsby Ltd., Montreal • **Western Ontario (Lakehead):** Northland Machinery Supply Co. Ltd., Fort William • **Manitoba & Saskatchewan:** Mumford, Medland Ltd., Winnipeg & Regina • **Alberta:** Gorman's Ltd., Edmonton • **British Columbia:** Ruston & Hornsby Ltd., Vancouver.

• Discussion

(Continued from page 84)

knowledge such direction does not exist in the form of specifications. For example, A.S.T.M. Specification E-164 entitled "Ultra Sonic Inspection of Weldments" requires a test plate to be welded up and a "Test Hole" to be drilled in it at a specific point. However, it also states that the dimensions of the hole are to be mutually agreed upon between the purchaser and the fabricator. This presumes that both parties thoroughly understand the principles and practises of this method. This can be (and most often is) erroneous and leaves one suspended in space since it gives no guidance on how to co-relate the hole size with signals which show flaws of acceptable magnitude, nor does it give any minimum standards of acceptance.

As far as fillet welded joints are concerned, this specification warns not to misinterpret the signals which reflect off the non fused edge of the plate at the root of fillet welds. In so doing, the specification raises the question "Can fillet welds be reliably inspected?".

With some experience an operator can make some shrewd guesses as to the nature of the discontinuity which causes the "pip" on his oscillograph since such signals can be caused by, lack of fusion, cracks, porosity, slag inclusions, undercuts, weld surface conditions (roughness), etc. Cracks usually result in a sharply defined signal. Other discontinuities such as porosity and slag, are not so accommodating and all one can conclude is that some form of discontinuity exists. Thus since the magnitude of the signal is no measure of the size of defect, the operator is in a predicament as he not only is ignorant of the true cause and size of the defect, but also has no standards of acceptance from which to judge.

Generally this method is considered to be the least suitable for the inspection of fillet welds and no doubt because of this, the problem is being studied. Several methods for the inspection of fillet welds have been developed using either a single probe or two probes. These methods are based on assumptions such as:

(a) the root of the fillet weld is perfectly straight,

(b) the shape and contours of the weld deposit are uniform throughout the length of the weld,

(c) the geometrical relationship between the assembled parts (such as flange and web of a girder) are true and constant throughout the entire member,

(d) the surface of the piece being inspected is very smooth.

Unfortunately in practise it is impossible to fulfill these assumptions since variations in arc voltage or welding speed will affect the penetration at the root of a fillet and straight line penetration will not be obtained. The shape and contour of the fillet is affected by the position of welding, the type of electrode being used, the number of beads or passes employed, the current used, etc. with the result that smooth, uniform geometrical shapes are not obtainable. Again, the surface of the piece being inspected is not very smooth since in general it will be in the "as received" condition and will have mill scale attached to it. The mill scale in all probability will exist in local patches and thus disturb the smoothness.

These are some of the conditions which mitigate against the process. Nevertheless, groups have continued to study the problem and the general conclusion is that it is possible to examine fillet welds under laboratory conditions providing very exacting techniques are carefully applied. However, for conditions outside the laboratory, (i.e. shop and field) the methods are too complex to ensure that they have been properly applied and in addition are very slow and would interfere with general production.

From the foregoing it can be seen that it is quite possible that ultrasonic inspection may not be the right answer for the inspection of welds, either from the economic or quality view point. It may also be seen that the skill and competence of the operator can have a profound effect on the results obtained and to date no controls have been set up to establish whether or not an operator is qualified to make the inspection.

The Division of Highways of the State of California have for years been experimenting with the use of Ultra Sonic testing of fillet welds. To date they find the procedure lacks reliability and have not been able to develop satisfactory standards. Therefore they do not use ultrasonic testing

for fillet welds but rely primarily upon visual inspection supplemented by dye penetrant or magnetic particle.

Author's reply:

The written discussions all come from engineers of prominence in the field of N.D.T. and Weld Quality Control and certainly enhance the value of the paper. Each individual has naturally dealt with those aspects of the subject which are of personal interest and it is significant that there is a broad area of agreement concerning the nature of the problems and also the urgency of the need to find practical solutions for them.

Mr. Gooderham has made specific proposals to assist the industry through the C.S.A. in setting up quantitative standards of weld quality acceptance for space frame structures and other types of specialized welded structures. He also reports progress in the direction of certification of welding inspectors and organizations as proposed by the author.

During a recent tour of Great Britain and the Scandinavian countries the author enquired into the European practice in the field, and it was apparent that these countries are making good progress. Dr. H. Vinter, director of a national welding and quality control organization in Denmark expressed the opinion that welding inspection personnel of an educational level equivalent to the chartered accountant, are required to operate efficient weld quality control programs. In his final paragraph Gooderham confirms the amendment to C.S.A. W59 permitting 100% efficiency in welded butt joints and it is assumed that some recommendation or requirements for N.D.T. examination is applicable to 100% butt weld joints. Mr. Barer has stated that his personal experience with welded warships and weapon systems is in general agreement with the concepts and philosophies expressed by the author. He also directs our attention to the data on the "Effects of Weld Defects" published in the "Proceedings of the 3rd International Conference on Non Destructive Testing held in Tokyo March 1960". Similar data is now being compiled by Commission V of the International Institute of Welding and a resolution was passed by that Body in Oslo, June 1962 stressing the need for the early completion of their own program of experimental work on this subject. At present, however, the author is not aware of any welding code in use in North America whose weld quality requirements, as determined by visual and non-destructive examination, are wholely (or directly) based upon quantitative research data concerning the effects of weld defects in a given service condition.

Messrs. Jehu and Gooderham have given their support to the author's views concerning the limitations of ultrasonics when employed on welded bridge girders and welded buildings. Mr. Jehu has pointed out that until such time as a recognized code authority publishes an acceptable ultrasonic testing standard which is directly applicable to the class of structure being fabricated; and a supply of specially trained and certified ultrasonic operators become available, the use of this inspection tool will remain of doubtful value and a source of disputes between architects, engineers and fabricators. The working Group C (ultrasonics) of Commission V, International Institute of Welding, reported in Oslo that Britain, Belgium, Denmark, France, Holland and Germany have experimental programs in progress on ultrasonic inspection methods for fillet welds. The special techniques, however, are not sufficiently developed at this stage to permit their use on welded bridges, rigid frame buildings and similar weldments. In addition they re-confirmed their report of New York 1961, stating that at this time it is not possible to use the amplitude of the echo appearing on the oscilloscope screen as a measure of weld defect size. Mr. Gooderham's report of failure in his efforts to find a satisfactory correlation between standard C.W.B. welding operators' qualification test pieces, which were tested first by ultrasonics, and then by mechanical semi-destructive bending is worthy of consideration.

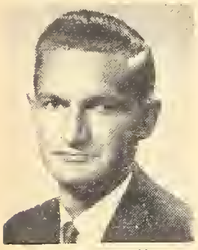
Mr. Havercroft who is responsible for the testing and certification of industrial radiographers, has set down the progress made to date and outlined the recent efforts directed towards the study of certification for ultrasonic and magnetic particle testing operators. He confirms the general lack of facilities for training N.D.T. operators in Canada and reports that the supply of trained personnel is falling behind the present needs of Canadian industry. Co-operation is clearly needed between all the interested groups to provide the necessary training facilities and this would seem to offer an excellent opportunity to the numerous vocational training schools and technical colleges which are now being provided by the Federal Government under a crash program.

In conclusion, all the discussions bring out different aspects of the paper, provide additional material, show wide understanding of the problems involved, and are sincerely appreciated. EIC

Personals

(Continued from page 52)

W. B. Hall, M.E.I.C. (Toronto '45) has been appointed Sales Manager of Canadian Porcelain Company Limited, Hamilton. Mr. Hall has had considerable experience in the electrical and industrial field.



W. B. Hall, M.E.I.C.

G. D. Sauer, M.E.I.C.

G. D. Sauer, M.E.I.C. (McGill '31) will spend three months in British Guiana, where he will make a preliminary survey of the country's water resources, under the United Nations program of technical assistance. Mr. Sauer is one of the many UN technical assistance experts who go abroad every year to advise governments, at their request, on the development of their economic and human resources.

M. L. Wade, M.E.I.C. (McGill '12) Councillor for the Central B.C. Branch of the Institute, has become associated with the firm of Wannop, Hirtle & Associates, Consulting Engineers.

R. D. Paterson has been appointed sales manager of the Rax-Fast Division, Avdel Limited, Toronto. Rax-Fast produces special systems for industrial storage racking. Mr. Paterson has been associated with the field of industrial protective coatings.

Robert F. Legget, M.E.I.C. (Liverpool '27), Director of the Division of Building Research of the National Research Council has been re-elected for a second three-year term to the 10-man Executive Committee of the International Council for Building Research, Studies and Documentation (C.I.B.).

R. J. Schneider, M.E.I.C. (Toronto '46), Vice President and General Manager of Canadian Dredge and Dock Co. Limited, has been elected to the Board of Directors of that Company. Mr. Schneider joined the Company in 1947 and has served in management capacities since that time. He is also Vice-President and Director of Bedford Construction Limited, and Russell Construction Limited, subsidiaries of Canadian Dredge and Dock.

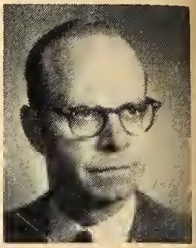
R. F. Legget, M.E.I.C.

R. J. Schneider, M.E.I.C.

H. W. R. Gibney, M.E.I.C. (U.B.C. '50) has been appointed Senior Planning Engineer, Mine Engineering, Sullivan Mine, Mines Division of The Consolidated Mining and Smelting Company at Kimberly, B.C.

Humphrey Style of Toronto, has been elected President of the Canadian Electrical Manufacturers Association. He will be responsible for guiding the Association which represents Canada's electrical manufacturing industry. Mr. Style has been President of John Inglis Co. Ltd., Toronto, since 1951 and has had many years of administrative experience.

Humphrey Style

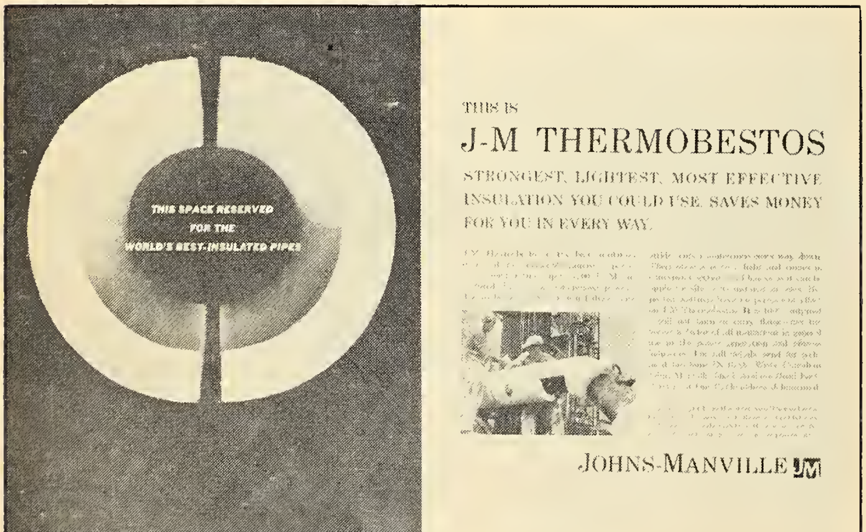


G. Jost, M.E.I.C.

George Jost, M.E.I.C. (McGill '32) has joined the Oceanair Travel Agency, Montreal. Prior to this, he was associated with the Beauharnois Power Corporation for two years, and with Canadian Industries for 24 years, serving in various sales capacities. During the last ten years at C-I-L, he was export sales and marine traffic manager. Mr. Jost is a member of the executive committee of the Canadian Inter-American Association, Montreal; and an export consultant with Dominion Consultants Corporation, Ottawa.

Fraser H. Fargey, M.E.I.C. (Manitoba '34) has been appointed manager of the Eastern District of De Laval Turbine Canada Ltd. Mr. Fargey has had over 20 years experience in the Canadian industrial field. The Eastern District covers Quebec and the Maritimes.

EIC CERTIFICATE OF ADVERTISING MERIT



Winner of the monthly award for the best advertisement in the September, 1962 issue was Canadian Johns-Manville Co. Ltd., with a black and white double-page spread, on behalf of their Thermobestos insulation.

The advertisement is particularly striking because the left-hand page is solid black except for a 6-inch photo of a cross section of the insulation required for a pipe, with the reader looking squarely down the length of it.

The right-hand page is headed "This is J-M THERMOBESTOS Strongest, Lightest, Most Effective Insulation You Could Use. Saves Money For You In Every Way." This is followed by good, reason-why copy and a smaller photo showing ease of installation.

The Advertising Manager of Canadian Johns-Manville Co. Ltd., is T. S. Patterson. The Agency is the Toronto office of MacLaren Advertising Co. Ltd., W. F. Burden, Account Executive.

Each month a different panel of 50 Journal readers from across Canada selects the award-winning-advertisement of their choice from the viewpoints of ACCURACY — INFORMATION — ATTRACTION.